NASA SP-7003

LUNAR SURFACE STUDIES

A CONTINUING BIBLIOGRAPHY

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

LUNAR SURFACE STUDIES

A CONTINUING BIBLIOGRAPHY

A Selection of Annotated References to Unclassified Reports and Journal Articles introduced into the NASA Information System during the period January, 1962- March, 1964.

Scientific and Technical Information Division
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
WASHINGTON, D.C. 1964

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INTRODUCTION

With the publication of this first issue of the Continuing Bibliography on "Lunar Surface Studies" (SP-7003), the National Aeronautics and Space Administration continues its program of distributing selected references to reports and articles on aerospace subjects that are currently receiving intensive study. All references have been announced in either *Technical Publications Announcements (TPA), Scientific and Technical Aerospace Reports (STAR), or International Aerospace Abstracts (IAA).* They are assembled in this bibliography to provide a reliable and convenient source of information for use by scientists and engineers who require this kind of specialized compilation. In order to assure that the distribution of this information will be sustained, Continuing Bibliographies are to be updated periodically through the publication of supplements which can be appended to the original issue.

The subject of Lunar Surface Studies is one which encompasses several scientific fields. As a consequence, this bibliography contains references to a variety of specific topics, including the theory of lunar origin, the lunar atmosphere, and the physical characteristics of the body such as its topography, geology, cartography, and stratigraphy. Techniques of lunar observation, measurement, and analysis, e.g., photography, photometry, and spectrophotometry, are amply covered, and pertinent references to the instrumentation and equipment used in lunar investigation have also been included.

Each entry in the bibliography consists of a citation and an abstract. The listing of entries is arranged in two major groups. Report literature references are contained in the first group and are subdivided according to their date of announcement in *TPA* and *STAR*. The second group includes published literature references, subdivided according to their date of announcement in *IAA*. All reports and articles cited were introduced into the NASA information system during the period January, 1962–March, 1964.

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1962

N62-10120 California Inst. of Tech., Pasadena.
ANNUAL REPORT FOR THE PERIOD DEC. 1, 1960 TO NOV. 30, 1961. PT. II—SUMMARY OF RESEARCH.
Harrison Brown and Bruce C. Murray. Jan. 1962. 62 p. 107 refs. (NASA Grant NsG 56-60) Available from OTS: ph $6.60, mi $2.06.

Photographic photometry was used in examining lunar reflectivity. Also, photoelectric color studies of the lunar surface were made for use in geological color mapping. The effects of the earth's atmosphere on the use of long wave length infrared photometry, in studying the surface of the moon and other solar bodies, were investigated. A study of the atmospheres of meteorites, asteroids, comets, and satellites of Jupiter and Saturn were made to determine if they contained simple compounds of oxygen, hydrogen, carbon, and nitrogen. An investigation of the stability of these volatiles should give some clue to their distribution in the solar system. Also, the composition of meteorites was determined by the use of X-Ray fluorescence analysis, and a statistical study of meteorite fall was conducted to determine the cause of the variations in abundance noted at different times.

N62-10123 Harvard Coll. Observatory, Cambridge, Mass.
STUDY OF INFRARED INSTRUMENTATION FOR THERMAL PHOTOGRAPHY OF THE MOON.
Hector C. Ingrao, Donald H. Menzel, and J. Anthony Burke. May, 1961. 58 [14] p. 60 refs. (Scientific Rep. No. 1) (NASA Grant NsG-64-60. Available from OTS: ph $7.60, mi $2.36.

Successful thermal photography, for the primary purpose of temperature measurement, depends on the value of the signal intensity at the ground, or in a baloon or space vehicle. Computations predict the image temperature, for an image-forming system with a single thermal detector having a sequential read-in and read-out. Thermal detectors and available single-quantum detectors with responses at wave lengths of approximately 5μ and longer are intercompared in terms of figures of merit. Infrared sensitive image-forming systems are surveyed and discussed for lunar thermal photography. Lateral heat conduction in the target plate of a simultaneous read-in image-forming system is analyzed to determine the size of the minimum resolvable element. On the basis of this analysis, the possible utility of new thermal detectors as target plates for image-forming systems of simultaneous read-in are investigated. The potentialities of ferroelectric materials for a target plate (thin film) of an image-forming system depend on the change in dielectric constant as a function of temperature close to the Curie point. Nonlinear phosphors, especially zinc cadmium sulfide, are considered for thermal image conversion. This phosphor fluoresces in the yellow and has a brightness change of approximately 28 percent per degree centrigrade for a given ultraviolet excitation, and phosphor temperature.

N62-10170 Radiation Lab., U. of Michigan, Ann Arbor.
ATLAS OF THE FAR SIDE OF THE MOON (PUBLICATION OF THE ACADEMY OF SCIENCES OF THE USSR, MOSCOW, 1960)
N. P. Barabashev, A. A. Mikhailov, and Y. N. Lipsky, eds. Translated by Nadya Winkels. Jan. 1961. 143 (20) p. 5 refs. (Report no. 2914-1-T) (NASA Grant NsG-4-59)

This atlas presents photographs of the far side of the Moon, and a map drawn in an equatorial orthographic projection to a scale of 1:10,000,000; it also describes and catalogs discovered formations according to categories of certainty. Analysis of the formations of the far side was carried out from the photographs which included portions of the visible side for reference. The formations were delineated and identified by photometric cross sections and finally superimposed on a coordinate network for final mapping.

The atlas was compiled from Wilkins' map of the visible side, and the photographs of the far side obtained by the Soviet interplanetary station (AIS) in October 1959. Negative images of photographs automatically developed on the AIS were transformed into electric signals; the signals were transmitted to Earth where they were recorded before demodulation, by a magnetic recording device which could provide negative or positive photographs directly on film or photographic paper.

N62-10199 Maryland U., College Park.
THE LUNAR ATMOSPHERE.
E. J. Opik. [1962] 59 p. 31 refs. (Tech. Rept. 240) (NASA Grant NsG 58-60) Available from OTS, ph $5.60, mi $1.97.

Optical and radio estimates of the upper limit of density of the lunar atmosphere are reviewed. Properties of the lunar ionosphere in contact with the surface are analyzed theoretically and applied to an estimate of its composition and density. Considering the balance between injection and escape, the daytime average probable number density at the surface is rated at 3 to 5 $\times$ 10^5 cm^{-3} with an uncertainty ratio of about 2 and with 50-70 percent CO_2, 45-27 percent H_2O and 4-2 percent H_2. The electron density, in equilibrium with contact recombination at the surface, is then 200-300 cm^3. The sources of the atmosphere are solar wind, its interaction with, and sputtering of, the surface, meteor impact degassing, and somewhat dubious "volcanic" sources. The surface electric charge is slightly negative or neutral; only when the total density falls below 3 $\times$ 10^4, and the electron density below 200, will there be a positive charge.

N62-10205 Army Map Service, Washington, D. C.
TOPOGRAPHIC LUNAR MAPPING AT THE ARMY MAP SERVICE
Albert L. Nowicki. Sept. 1961. iv, 20 p. (Tech Rept. 37)

With the advent of the space age and subsequent studies suggesting the possibility of landings on the moon the requirements for a

topographic lunar map became apparent. This report describes the steps taken by the Army Map Service, Corps of Engineers, U. S. Army, to prepare such a map of the visible surface at a scale of 1:5,000,000 with 1000-meter contours (plus 500-meter auxiliary contours) on a modified stereographic projection

N62-10267 Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena.
SCIENTIFIC EXPERIMENTS FOR RANGER 3, 4, AND 5.
Dec. 1961. 25 p. 10 refs. (JPL-TR-32-199) (NASA Contract NASw-6).

This report presents descriptions of the scientific experiments to be carried on Ranger 3, 4, 5 spacecraft—the first spacecraft designed to land operating instrument packages on the Moon's surface. The experiments include a vidicon camera to obtain close-up pictures of the Moon's surface and show small-scale geological land forms and features. A gamma-ray experiment will determine the approximate concentration of the different radioactive materials present in the surface of the Moon. An altimeter will obtain radar reflectivity data. These data should be valuable in the determination of the lunar surface structure. A seismometer will be landed to obtain data regarding the inner structure of the Moon and the magnitude and depth of any thermal activity.

N62-10292 National Aeronautics and Space Administration, Washington.
REPORTS OF OBSERVATORIES, 1960-61—NASA.
Nancy G. Roman. Repr. from Astron. J., v. 66, no. 9, Nov. 1961 (no. 1294). p. 463-465. ADDENDUM, Astron. J., v. 66, no. 10, Dec. 1961. (no. 1295).

Scientific satellite and rocket probes in 1960-1961 have yielded much new information on the upper atmosphere. The data from Echo I, Explorers VIII, IX, X, XI, Pioneer V and various rocket flights are evaluated. Echo I information determined the atmospheric density at 1500 km as approximately 10^{-18} g/cm^3. Explorer VIII measured the mass and spatial distributions of interplanetary dust particles over a large mass range. Explorer IX gave an atmospheric density value of 3×10^{-17} g/cm^3 at 700 km. Explorer X mapped the magnetic fields and particle fluxes as a function of geocentric distance along its orbit. Explorer XI detects extraterrestrial high energy gamma rays in the 100 Mev region from neutral π meson decay. Pioneer V probed the 11-year variation in cosmic ray intensity, the boundary of the geomagnetic field between 10-and-20 earth radii and interplanetary geomagnetism. Rocket probes indicate that the atmosphere is isothermal between 350 km and 625 km, with a postulated temperature of 1650° K. Rocket probes also obtained low dispersion spectra for 10 stars between 1600A and 4000A; data on spectrum of solar protons following a solar flare; and data on changes in the energy spectrum of the inner belt with magnetic latitude.

Ground support studies for these space probes include analysis of the rigid-body motion of bodies in orbit, positional systems accuracy checks, star position documentation, and studies of lunar and circumlunar space vehicle trajectories for 1963-1968. A computing procedure for determining earth-satellite orbits from radio and optical tracking data has been developed. Studies on the micrometeoroid penetration hazard in various structural materials on the error of calculating meteor mass loss from light intensity observations, and on textile origin are reviewed. The interaction between solar corpuscular streams and the geomagnetic field was investigated. Radar contact with Venus was established, and power spectrum analysis of the signal indicate that Venus has an extremely slow rotation rate. A new value for the astronomical unit, 149598 700 ± 500, was established from this radar contact. Development of instrumentation for planetary surface probes is mentioned. Meteorite composition, atmospheric models of Jupiter and Venus, and the thermal and stress history of the moon are being studied.

N62-10332 Cornell U., Ithaca, N.Y.
ELECTROSTATIC EROSION MECHANISMS ON THE MOON.
P. D. Grannis. Repr. From J. Geophys. Research. v.66, no. 12, Dec. 1961. p. 4293-4299 13 refs. (NASA Grant NsG-119-61)

The electrostatic processes which have been suggested by Gold as being responsible for erosion of the lunar features are evaluated. The statistics of the charge build-up on the grains of lunar dust due to the solar gas streams are considered. On the basis of the derived probability distribution for grain charge, the electrostatic hopping effect is shown to result in an erosion rate which is lower by a factor of at least 10^2 than that rate indicated by observations of the moon. It is found that, owing to the supporting action of the electronic space charge, positively charged dust grains may be levitated above the surface. The mass transport resulting from the "downhill" gliding of such levitated grains may be sufficient to explain observed lunar erosion.

N62-10374 Michigan U., Ann Arbor.
CHARACTERISTICS OF THE MOON'S SURFACE LAYER: AN ANALYSIS OF ITS RADIO EMISSION.
A. Giraud. Repr. from Astrophys. J., v. 135, no. 1, Jan. 1962. p. 175-186. 34 refs.
(NASA Grant NsG-4-59; Subcontract 133-S-101 (DA 49-018 eng-2133 E, Army Map Service) with the Autometric Corp.)

A theoretical analysis of the thermal radio emission from the moon is carried out which takes into account the results of lunar radar reflection experiments, and all the available observational data are reviewed. Comparison between theory and experiment then yields the ratio of thermal to electromagnetic absorption as a function of wavelength, and good agreement with the observations is found. Estimates for the average dielectric constant, electrical conductivity, thermal conductivity, and volumetric specific heat are given, as well as for the depth of the surface layer and the size range of the granules which are thought to constitute it. These are based on and thus agree with results of radar and radio, as well as infrared and optical measurements. The picture which thus emerges for the lunar surface is that of a layer, possibly very deep on the low grounds and thin on the highlands, of a material in a somewhat degenerate state (possibly radiation-damaged), with a low density (probably increasing with depth) and a loose structure. The expected range of granule sizes is between 10 and 300μ. A plausible set of physical constants should include a dielectric constant of between 1 and 1.5, a thermal conductivity of order 5×10^{-4} to 10^{-3} cal sec^{-1}cm^{-1} deg^{-1} and a volumetric specific heat of about 0.1 or 0.2 cal deg^{-1}cm^{-3}.

N62-10404 Rand Corp., Santa Monica, Calif.
STUDIES OF THE PHYSICAL PROPERTIES OF THE MOON AND PLANETS.
Quarterly Technical Progress Report (6).
Comp. by M. H. Davis. Dec. 1961. 12 p.
(RM-3022-JPL) (Contract N-33561 (NASw-6)

Company research is proceeding in the following fields: (1) *Light scattering and radiative transfer.* The Chandrasekhar X and Y functions are being computed for optical thicknesses greater than unity in order to provide results for dense or extensive atmospheres; a mathematical investigation of the radiative-transfer problem has shown that certain properties which had formerly been assumed for the X and Y functions do not, in fact, hold. Elsasser-band models have been found that fit laboratory measurements of the infrared-absorption spectrum of carbon dioxide to within about 10 percent. (2) *Planetary atmospheres.* A paper has been completed which summarizes variations of pressure, temperature, and density with altitude for the Martian atmosphere; also, theoretical analysis of the seasonal atmospheric circulation of Mars has been completed. (3) *Planetary experiments.* An entirely different concept is being considered for moving the exploring instruments about the surface of the planets in unmanned planetary explorations: it is believed that a balloon could be used for measurements of planetary

atmospheres or for transporting suitable instruments from the landing point to other areas. (4) *Lunar and planetary geology and magnetism.* Papers completed and in progress discuss the optical ellipticity and internal structure of Mars, the age of the Earth-Moon system, and the magnetic fields of Mars and Venus. A harmonic analysis of lunar typography is under way.

N62-10434 Military Geology Branch, Geological Survey, Washington, D.C.

ENGINEER SPECIAL STUDY OF THE SURFACE OF THE MOON: PHYSIOGRAPHIC DIVISIONS OF THE MOON; GENERALIZED PHOTOGEOLOGIC MAP OF THE MOON; LUNAR RAYS; TEXT.

Comp. by Robert J. Hackman and Arnold C. Mason. July 1960. 3 maps (scale 1:3,800,000), 1 table 38 ¾" x 56¾"

The study consists of three maps and a table and is based on a photogeologic analysis using spectroscopic vision to examine matched photographs of libration pairs in the same lunar phase. A photomosaic of the moon was used for a base. A table gives a description and an evaluation of the physiographic regions of the moon with a glossary and selected lunar data. One map, the "Physiographic Division of the Moon", divides the moon into physiographic regions. The major divisions consist of lunar highlands, containing a majority of the craters, and lunar lowlands, mainly consisting of the maria. Each of these are divided into divisions, the divisions into provinces, and the provinces into sections. The boundaries and special interest features are included. Another map, the "Generalized Photogeologic Map of the Moon", divides the rock divisions on the surface into Pre-Maria, Maria and Post-Maria age. The nature of craters with their possible origin, faults, fractures, anticline, monocline and other features are given. The third map, "Lunar Rays", shows only the prominent rays and, where determinable, the crater, with encircling halos, from which the rays originated are indicated.

N62-10473 National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, Md.

CELESTIAL GEODESY.

W[illiam] M. Kaula. Washington, NASA, Mar. 1962. x, 120 p. 280 refs. (NASA TN D-1155) OTS, $2.50.

The geodetic use of rockets, artificial satellites, and the moon is reviewed. The discussion covers in turn dynamics, geometry, observational techniques, comparison with terrestrial geodesy, and geophysical implications.

N62-10559 Michigan U., Ann Arbor.

RADIO CHARACTERISTICS OF LUNAR SURFACE MATERIAL.

K. M. Siegel. [1961?] 11 p. 13 refs.

(NASA Grant NsG-4-59) OTS: ph $1.60, mi $0.80

The different theories of radio scattering from the Moon are compared and analyzed. The different theories pertinent to the subject, involving radiation from the Moon, are discussed. The electromagnetic and thermodynamic constants of the lunar surface are obtained. The conclusion is reached that present experimental data yields completely consistent results (independent of the wavelength of the radiation, whether the source is coherent or incoherent and independent of the pulse length used). The electromagnetic constants obtained are different from those found on Earth. (Author Abstract)

N62-10726 California Inst. of Tech., Pasadena

ON THE POSSIBLE PRESENCE OF ICE ON THE MOON.

Kenneth Watson, Bruce Murray, and Harrison Brown. Repr. from J. Geophys. Research, v. 66. no 5, May 1961. p. 1598-1600. 8 refs.

(NASA Grant NsG 56-60)

Water in the form of ice may exist in appreciable quantities in shaded areas of the moon. The reason for this thinking is that water is far more stable on the lunar surface than SO_2 or the noble gases, whose presences have previously been suggested. The rate of escape of water from the lunar surface is estimated to be 1.6×10^{-14} g/cm^2/sec. Over the life span of the moon the total loss would then be 2.3×10^3 g/cm^2; the total lunar atmospheric water mass being 4.2×10^6 grams. In addition to juvenile water, water is being added sporadically as the result of meteorite impact. Hence, the mass loss of water may be compensated to some extent by meteorite impact. Therefore, local concentrations of ice on the moon would appear to be well within the realm of possibility. Unfortunately, because ice, if it exists, will be in the permanently shaded areas of the lunar surface, attempts to determine whether it is present must await the time when suitable instruments can be placed in those areas. (R.G.S.)

N62-10728 California Inst. of Tech., Pasadena

THE BEHAVIOR OF VOLATILES ON THE LUNAR SURFACE.

Kenneth Watson, Bruce C. Murray, and Harrison Brown. Repr. from J. Geophys. Research, v. 66, no. 9, Sept. 1961. p. 3033-3045 33 refs.

(NASA Grant NsG 56-60)

Volatiles, and water in particular, have been thought to be unstable on the lunar surface because of the rapid removal of constituents of the lunar atmosphere by solar radiation, solar wind, and gravitational escape. The limiting factor in removal of a volatile from the moon, however, is actually the evaporation rate of the solid phase, which will be collected at the coldest points on the lunar surface. A detailed theory of the behavior of volatiles on the lunar surface based on solid-vapor kinetic relationships is presented, showing that water is far more stable there than the noble gases or other possible constituents of the lunar atmosphere. Numerical calculations indicate the amount of water lost from the moon since the present surface conditions were initiated is only a few grams per square centimeter of the lunar surface. The amount of ice eventually detected in lunar 'cold traps' thus will provide a sensitive indication of the degree of chemical differentiation of the moon. (Author Abstract)

N62-10756 Antenna Lab., Ohio State U. Research Foundation, Columbus.

A THEORETICAL MODEL FOR SCATTERING FROM ROUGH SURFACES, WITH APPLICATIONS TO THE MOON AND SEA.

Randolph H. Ott. Nov. 10, 1961. 42 p. 24 refs.

(Report 1388-1) (NASA Grant NsG 213-61)

OTS: ph $4.60, mi $1.46.

The problem of the interaction of electromagnetic radiation with nonuniform surfaces is approached statistically. By suitable choice of the second probability distribution for the surface, one finds the calculated back-scattering cross-section to depend exponentially on the angle of incidence.

Upon comparison of the calculated scattering cross-section and measured lunar and terrestrial returns, one finds that the model can account for the scattering from a rough surface out to incidence angles of nearly 30°; the model prescribes slopes for the lunar surface up to 15°. One finds also that the model can account for the measured power reflection coefficient of the lunar surface. (Author Abstract)

N62-10804 California Inst. of Tech., Pasadena

THE DENSITY AND MASS DISTRIBUTION OF METEORITIC BODIES IN THE NEIGHBORHOOD OF THE EARTH'S ORBIT.

Harrison Brown. Repr. from J. Geophys. Research, v. 65, no. 6, June 1960. p. 1679-1683. 3 refs. (NASA Grant NsG 56-60).

A study of the frequency of meteorite falls in areas which have been highly populated throughout the last century indicates that the average rate of fall of meteorites on the earth probably lies between 0.32 and 1.0 falls/year 10^6 km^2. The frequency of fall as a function of type and

mass has been studied, and it is shown that the distribution curves for stones and irons have similar shapes. The curves are also remarkably similar to those observed for asteroids. The observed relationships are used to calculate the impact frequency of meteoritic particles upon the earth and moon as a function of their size. (Author Abstract)

N62-10933 Joint Publications Research Service, Washington, D. C.
THE ENERGY NECESSARY FOR THE CREATION OF LUNAR CRATERS AND RING MOUNTAINS.
Peter Hedervari (Hungarian State "Lorand Eotovos" Geophys. Inst.) Feb. 12, 1962.
(JPRS-12458; CSO-10-N) Partially summarized and translated from Magyar Fizikai Folyoirat, v. 1, no. 4, 1961, p. 251-263.

Every indication seems to point to the fact that the majority of lunar craters (with a diameter equal to or less than 20 kilometers) and the ring mountains (with diameters in excess of 20 kilometers) were created by internal lunar forces. This paper intends to show that the available energy of lunar dilatation is far greater than that necessary for the creation of these formations. By applying the formula of thermal energy developed for volcanic islands, it can be concluded that, depending on the diameter, the necessary thermal energy is 10^{25} to 10^{30} ergs. It will also be shown that the energy requirements of the largest ring mountains are in the order of that consumed in the creation of the Mauna Loa volcano in Hawaii. This energy is about 5.6×10^{5}-times as much as that of the strongest shock wave of the 1960 earthquake in Chile. (Author Abstract)

N62-11141 Center for Radiophysics and Space Research, Cornell U., Ithaca, N. Y.
HYDROGEN NEAR THE MOON.
Robert J. Gould. Apr. 1962. 6 p. refs.
(CRSR-114) (NASA Grant NsG-119-61)
OTS: ph $1.10, mi $0.80.

Hydrogen near the moon is studied to ascertain whether the re-evaporated gas will be in molecular or atomic form. This knowledge is necessary for the detection of this temporary atmosphere. Low energy (~5 KeV) solar protons strike the lunar surface and penetrate (thus picking up an electron) and diffuse out to the surface to be evaporated away either as atoms or, if they encounter another hydrogen atom, as molecules. A slow diffusion rate would give the lunar surface a high concentration of interstitial embedded hydrogen atoms and these atoms, in diffusing through the solid, are likely to encounter another atom and combine with it. A high diffusion rate, on the other hand, would lead to rapid escape from the solids as atoms. Equations show a high rate of diffusion, which indicates that outgoing hydrogen will leave the surface at thermal velocities and in atomic form. Molecular formation seems to be a minor process only. (I.v.L.)

N62-11253 Air Force Cambridge Research Labs. Geophysics Research Directorate, Bedford, Mass.
LOCATION OF A LUNAR BASE.
John W. Salisbury and Charles F. Campen, Jr. Oct. 1961. ix, 44 [3] p. 113 refs.
(GRD Research Notes 70; AFCRL-870) (Proj. 7698)

All pertinent factors governing lunar base location have been discussed and an initial site suggested accordingly. The two major theories of lunar substructure are reviewed as pertinent to the location of a lunar base. The meteoric theory, to which the authors subscribe, favors a moon base located in the highlands where the collapse hazard is at a minimum. Lunar probes for experimental verification of these conclusions are discussed; experimental verification, in addition to the Ranger series probes, is proposed. Surface characteristics would not particularly limit base location, but natural resources play a most important part. Mineral deposits must be large, centralized, and predictably located. It is suggested that vital water deposits may be found beneath chain craters and rilles, again suggesting a highlands location. The lunar base will have important consequences for astronomical research. Two observatories located 180° apart on the equator can continuously monitor the entire celestial sphere. Aspects of the lunar base as a communications relay also suggest two equatorial sites 180° apart to maintain virtually constant contact. The per capita, per day needs for oxygen, nitrogen, and water of lunar-based personnel are detailed; solar energy as a power source for mineral extraction is proposed. The initial location of a space vehicle terminal is limited by present propulsion systems to the western quadrant of the visible lunar face. Because of tremendous surface variations in temperature, the major lunar base complex would be underground. After detailed consideration of all the foregoing factors, a site south of the Hyginus Rille, near the crater Agrippa, is suggested for an initial lunar base site. (Author Abstract)

N62-11284 Rand Corp., Santa Monica, Calif.
STUDIES OF THE PHYSICAL PROPERTIES OF THE MOON AND PLANETS.
Quarterly Technical Progress Report (3).
Comp. and ed. by M. H. Davis. Apr. 28, 1961. 97 p. refs.
(RM-2769-JPL) (JPL Contract N-33561 (NASw-6))
OTS: ph $8.60, mi $3.†1.

The following basic studies are included in a summary reporting research conducted on the properties of the moon and planets: (1) Some of the methods of modern abstract operator theory have been applied (Mullikin) to the theory of radiation transfer, and important simplifications have been made in the theoretical development. (2) Discrepancies between optical and dynamical analyses of the shapes of the earth, moon and Mars may be accounted for by a theory proposing that phase changes in the minerals of the rock mantle cause density variations which possibly contribute to gravitational fields of the planets while permitting isostatic equilibrium. (3) Owing to the greater resolution of radiation measurements from planetary probes, infrared measurements from the Mars capsule should make it possible to determine whether the Sinton bands are due to gaseous absorption or to the surface's reflective properties. The CO_2 concentration in the Venus atmosphere can be determined with precision from measurements of scattered solar radiation in the ultraviolet. (4) Preliminary estimates of air densities in the earth's exosphere have been based on the orbit of Echo I. A new method of analysis is presented which includes the effects of radiation pressure. (5) In evaluating the future role of surface, balloon, and satellite observatories, and planetary probes, it is shown that much would be gained by an intensive coordinated program of observation from ground observatories, from platforms outside earth's atmosphere, and from probe vehicles. (6) Strong evidence is presented (Kaplan) against a recently published interpretation (Kiess, Karrer, and Kiess) that certain spectra indicate the presence of nitrogen oxides in the Mars atmosphere. It is shown in contradiction to this interpretation that no more than trace amounts of nitrogen peroxide can exist on Mars or Venus. (7) A method has been suggested by which the mean molecular weight of the gases in the Mars atmosphere might be determined from measurements of pressure and velocity made on the Mariner B capsule during its free-fall descent. It has been speculated that the Mars atmosphere may be like the atmosphere of Earth above the 10-km level. Also, on the basis of a thorough analysis, it has been concluded that the mean temperature of the air near the Mars surface is somewhat lower than had been generally suspected, being about -25°C day and night at 1 km above the Mars equatorial surface. (8) The published values of the surface gravity on Mars are discussed, and words of caution are given on how they should be used. (9) Despite the consistency of investigation results on the surface pressure of Mars, the likelihood of systematic errors could lead to a 50 percent error in reported values. (V.D.S.)

N62-11286 Rand Corp., Santa Monica, Calif.
STUDIES OF THE PHYSICAL PROPERTIES OF THE MOON AND PLANETS.
Quarterly Technical Progress Report No. 5, July 1-Sept. 30, 1961.
Comp. and ed. by M. H. Davis and S. M. Greenfield. Sept. 1961. 56 p. 14 refs.
(Memo. RM-2900-JPL) (JPL Contract N-33561; NASA Contract NASw-6)
OTS: ph $5.60, mi $2.00.

Basic research studies on the properties of the moon and the planets deal with: (1) possibility of the Martian blue haze being produced by solar protons; (2) radiative temperature distribution in a planetary atmosphere; (3) study of planetary atmospheres by stellar occultations; (4) general circulation of planetary atmospheres, (5) use of a parachute in the Mars atmosphere; (6) age of the earth-moon systems; and (7) optical ellipticity and internal structure of Mars. (J.R.C.)

N62-11460 Air Force Cambridge Research Labs., Geophysics Research Directorate, Bedford, Mass.
SPACE AND PLANETARY ENVIRONMENTS.
Shea L. Valley, ed. Jan. 1962. 220 p. 288 refs.
(Air Force Surveys in Geophysics-139; AFCRL-62-270)

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1. INTERPLANETARY GAS AND MAGNETIC FIELDS. Marvin L. White and A. A. Wyller. Aug. 1961. p. 1-13. 32 refs.
2. THE TERRESTRIAL MAGNETIC FIELD. Paul Fougere. June 1961. p. 15-31. 30 refs.
3. THE EXTERNAL TERRESTRIAL GRAVITY FIELD. Bela Szabo. June 1961. p. 33-39. 29 refs.
4. CORPUSCULAR RADIATION IN THE VICINITY OF EARTH. Shea L. Valley. Oct. 1961. p. 41-62. 22 refs.
5. SOLAR ELECTROMAGNETIC RADIATION. H. E. Hinteregger. June 1961. p. 63-90. 10 refs.
6. THE LUNAR ENVIRONMENT. John W. Salisbury. July 1961. p. 91-126. 62 refs.
7. PLANETARY ENVIRONMENTS. John W. Salisbury. July 1961. p. 127-161. 40 refs.
8. SPACE ENVIRONMENT OF THE SOLAR SYSTEM. Gordon W. Wares. Nov. 1961. p. 163-220. 63 refs.

N62-11710 Maryland U., College Park.
SURFACE PROPERTIES OF THE MOON.
Ernst J. Öpik. Repr. from Progress in the Astronautical Sciences, S. F. Singer, ed. Amsterdam, North-Holland Publ. Co., 1962. v. 1, p. 219-260. 56 refs.
(NASA Grant NsG-58-60)
OTS: ph $5.60, mi $1.73.

The origin of the **lunar crater** in meteoritic impact is beyond doubt; only a few minor formations are apparently of volcanic origin. The craters on the lunar continents belong to the final stages of accretion of the Moon. The primeval craters have been obliterated in the maria, which only carry the imprints of the less numerous later collisions with the stray bodies of the solar system. The phase law points to a rough surface covered with opaque grains or elevations. The increase in contrast of the bright rays and dark spots near Full Moon can also be explained by a greater or smaller degree of roughness of these markings, as compared with the average surface. The **dynamical shape** of the Moon as characterized by its principal moments of inertia would be equivalent to an uncompensated bulge of 1.1 km directed towards the Earth, and one of 0.8 km at right angles in the equatorial plane; it cannot be easily interpreted as a "frozen-in" fossil tidal bulge. Contrary to widespread opinion, the geometrical shape of the lunar surface is closer to spherical than the dynamical shape of the Moon as a whole. The average level of the maria is 2.52 ± 0.13 km below that of the continents. The density of the **lunar atmosphere**, probably very much less than 10^{-16} g/cm^3, can exceed that of interplanetary space by 2-3 orders of magnitude at most. The **lunar dust layer** equally covers the mountain slopes and the plains, and cannot possess any appreciable degree of fluidity. The dust layer is thin, of the order of 5 cm on the slopes, 20-100 cm on the plains. The small differences in level suggest a high degree of plasticity of the lunar crust under the continents some 10 km below the surface. A steep thermal gradient in the outermost insulating layer of dust and rubble may be the cause. In the maria the bedrock, if consolidated by previous melting, would have a higher conductivity and a lower thermal gradient except in the outermost layer of dust. From the standpoint of lunar landings there should be adequate superficial support anywhere but, in view of the consolidated base, the maria are preferable. The absence of considerable aftereffects of past tidal distortions of lunar craters shows that the craters were formed at a distance of 30000-50000 km or more, when the Moon was already receding from the Earth in its tidal evolution. In the light of the collisional probability theory of accretion from fragments, a consistent model requires that the Moon was formed from a ring of fragments orbiting the Earth, and not directly from interplanetary material. At a distance of 37000 km, the time interval of formation may have been about 80 years, with 4 years as the final stage when the craters on the continents were imprinted.

(Author Abstract)

N62-11754 New Mexico U. Engineering Experiment Station, Albuquerque
RADAR BACK-SCATTER THEORIES FOR NEAR-VERTICAL INCIDENCE AND THEIR APPLICATION TO AN ESTIMATE OF THE LUNAR SURFACE ROUGHNESS.
Harbhajan S. Hayre and Richard K. Moore. Jan. 1962. 291 p. 167 refs.
(EE-67) (NASA Grant NsG-129-61)
OTS: ph $18.50, mi $8.93.

A statistical model of a rough surface based on the roughness data obtained from contour maps of various types of terrains in the U.S.A. is set up and used to calculate the radar-scattering cross section per unit area. These calculations are made possible since the surface height is shown to have a normal distribution for many naturally occurring rough terrains; the surface height functions belong to a Gaussian random process. Also, the data from the contour maps show that the spatial height distance autocovariance function can be reasonably well approximated by an exponential function.

The modified Kirchhoff-Huygens' principle is used to calculate the received electric field from an incremental area on the rough surface. The Poynting vector is employed to obtain the return power and the aperture effect of the receiving antenna. The result is expressed in terms of the modified spherical variables. The phase effect due to the change in range caused by surface perturbations is expressed in terms of these new variables and the random height variables. The average of the return power is then calculated using normal probability density function. The resulting expression is integrated to give the radar-scattering cross section per unit area. The experimental radar return from terrain and the Moon is shown to verify this type of representation.

This theory is used to determine a transitional value (which is in agreement with previously reported results) of the ratio of radar-scattering cross section to wavelength in going from a quasi-smooth surface to a rough surface. A ratio of reference specular to apparent scatter is introduced as a measure of the surface roughness, and its usefulness is demonstrated using acoustic simulator data on many types of rough surfaces.

Lunar radar echoes are acoustically simulated. Nonlinear acoustic modeling techniques used in this experiment are theoretically justified, and the experimental results indicate that the lunar spatial autocovariance function is of exponential form. The presently available lunar echo data, however, are insufficient to give any indication of the presence or absence of dust layers on the surface of the Moon. The average dielectric constants of the lunar surface cannot be precisely calculated from the existing data. (J.R.C.)

N62-11797 Physikalisches Institut, U. of Berne (Switzerland)
STUDIES ON THE RADIOACTIVE DATING OF THE LUNAR SURFACE. Status Report.
P. Eberhardt and J. Geiss. Jan. 19, 1962. 7 p. refs.
(NASA Grant NsG-157-61)
OTS: ph $1.10, mi $0.80.

A gas extraction and purification apparatus, suitable for remote control, has been developed for the determination of isotope concentrations of rare gases in lunar surface material. The apparatus can be used to obtain radiation ages from abundances of argon, neon, and helium isotopes; and argon potassium, helium-uranium-thorium, and xenon-iodine ages can be estimated. The apparatus uses chemical energy without an additional energy supply and neither gives off gases nor creates mechanical shocks. The apparatus consists primarily of a molybdenum tube with a titanium sponge mounted inside it. The system is enclosed in a cylindrical box to prevent leakage of gases from chemical reactions; total weight is 600 gms, which can probably be reduced about 30 percent. A sample is melted and degassed in the tube, using heat from a FeO-Al reaction. The titanium sponge absorbs all but the rare gases. The apparatus has been tested by extracting argon from chondritic samples. The yield for A^{40} was better than 98 percent; for A^{36} and A^{38}, better than 90 percent. The apparatus can also be used for determining of primordial rare gases and volatile components and a detailed study of the lunar atmosphere. Remote controlled dating methods, developed for lunar investigation, could be applied to other bodies of the solar system. (M.P.G.)

N62-11806 Rand Corp., Santa Monica, Calif.
STUDIES OF THE PHYSICAL PROPERTIES OF THE MOON AND PLANETS.
Quarterly Tech. Progress Report (7).
Apr. 1962 21 p. refs.
(AR-15-JPL) (JPL Contract N-33561(NAS7-100))
OTS: ph $2.60, mi $0.83.

Significant highlights of studies of the physical properties of the moon and planets were as follows: (1) Computers are used to calculate the Chandrasekhar X and Y functions for large values of Tau by the iteration process, assuming applicable approximations for the Tau parameter. Other innovations used to obtain solutions were as follows: "correction" formula applied between iteration, the "standardization" of the Chandrasekhar functions for the case $\psi 3$, and variations in the iteration scheme. (2) Several provisional models to illustrate the Martian atmosphere were built, and their validity is being tested by calculating the heating rates within an atmosphere. (3) The scattering and polarization properties for haze particle distributions are being calculated to aid in processing Mariner-B space probe observations, in evaluating Dolfus' measurements on Martin haze, and in testing the hypothesis that similar particles are responsible for both notilucent clouds on earth and for the Martin blue haze. (4) The lunar surface may consist of finely-divided material that would permit a certain penetration of solar radiant heat creating subsurface layers warmer than the surface at midday on the moon. During an eclipse, this would delay the fall of surface temperature. (5) If the lunar surface is made up of small grains that are charged, this material could have two stable conditions: a solid, with its grains cemented together by electrostatic image forces; the other, a tenuous dust-cloud with grains held apart by electrostatic Coulomb forces. (6) For the equatorial bulge of Mars to be isostatically compensated, the depth of compensation cannot be greater than about 226 km since the percentage of crustal rock must be at least an order of magnitude greater than that in the earth. (7) Movement of the earth's axis of rotation relative to the crust of the earth will cause an asymmetrical distribution of material which is not in phase equilibrium. This asymmetric distribution of material results in a dynamic equilibrium that permits polar motion of a restricted rate. (M.P.G.)

N62-11907 Joint Publications Research Service, Washington, D. C.
HOW A PICTURE OF THE OTHER SIDE OF THE MOON WAS OBTAINED.
Geral'd Borisovich Bogatov. Feb. 19, 1962. 68 p.
(JPRS-12543)
Transl. of Kak bylo polucheno izobrazheniye obratnoy storony Luny. S. I. Katayev, ed. Moscow-Leningrad, State Power Engineering Pub. House, 1961. p. 1-64.
Distributed by OTS.

N62-11926 Joint Publications Research Service, Washington, D. C.
STARS ON THE WIRE.
V. Chernikova. Mar. 27, 1962. 11 p.
(JPRS-13160)
Transl. from Nedelya (Moscow), no. 52, Dec. 1961. p. 18.
Distributed by OTS.

N62-12050 Maryland U., College Park.
DENSITY OF THE LUNAR ATMOSPHERE.
E. J. Öpik and S. F. Singer. Repr. from Science, v. 133, no. 3462, May 5, 1961. p. 1419-1420. 14 refs.
(NASA Grant NsG-58-60)

The consequences of a model are worked out in which the lunar atmosphere is formed by gravitational accretion of interplanetary gas. Our results differ from those of Firsoff and of Brandt, partly because of the inapplicability of the barometric equation to the case of an exosphere. (Author Abstract)

N62-12164 National Aeronautics and Space Administration. Langley Research Center, Langley Station, Va.
FEASIBILITY STUDY OF A CIRCUMLUNAR PHOTOGRAPHIC EXPERIMENT.
William H. Michael, Jr., Robert H. Tolson, and John P. Gapcynski. Washington, NASA, May 1962. 39 p. 13 refs.
(NASA TN D-1226)
OTS: $1.00.

A study has been made to investigate the feasibility of a high-resolution, lunar-surface photographic experiment, with the use of a circumlunar trajectory and with recovery of the film on return to the surface of the earth. Particular attention has been given to procedures for obtaining high-resolution photographs of the lunar surface, for returning the undeveloped film to the earth, and for recovering the data package on completion of such a mission. As an example of a typical existing vehicle which could be used for such an experiment, the characteristics of the Ranger spacecraft have been used in applicable portions of the study. (Author Abstract)

N62-12436 Lamont Geological Observatory, Columbia U., Palisades, N.Y.
DESIGN AND CONSTRUCTION OF A LUNAR SEISMOGRAPH. Progress Report 11, 1 Jan. to 31 Mar. 1962.
[Apr. 1962] 7 p.
(NASA Contract NASw-82)
OTS: ph $1.10, mi $0.80.

Preparation for handling and analyzing Ranger data and theoretical studies to improve techniques for interpretation of lunar seismic information have continued. The prototype Surveyor seismometer system has been fabricated, and initial operational and environmental tests were satisfactory. An analog technique has proved very successful for identifying earthquake phases by separating data of horizontal shear wave energy, vertical shear wave energy, and compressional wave energy directly on tape recorders. This technique should prove extremely valuable for analyzing lunar data. Equations for lunar tides have been programmed for the IBM 7090 at the Jet Propulsion Laboratory, and first results are being evaluated. Fabrication and preliminary testing of the Surveyor seismograph prototype have been completed, and the system is undergoing operational evaluation before delivery to the Jet Propulsion Laboratory. Vibration test results of a seismograph mockup indicate that severe resonant vibrations which existed in the rigidly mounted fixture can be effectively isolated.

Investigations are underway to evaluate dry film lubricants for several parts of the seismograph system. (V.D.S.)

N62-12445 Space Sciences Lab., U. of Calif., Berkeley.
RESEARCH REPORT OF ELEMENTAL ABUNDANCES OF THE LUNAR CRUST ACCORDING TO RECENT HYPOTHESES.
Ann Palm and Robert G. Strom. Jan. 1962. 56 p. 30 refs.
(Ser. 3, issue 5) (NASA Grant NsG-145-61)

Some of the recent hypotheses of the origin of the moon and its surface features are reviewed, and a most probable set of elemental abundances of the lunar crust is deduced for each hypothesis by comparing these rock types with common terrestrial ones, meteorites and tektites. The present study indicates that the lunar crust may be composed of aerolitic, acidic or basic rock types. Depending upon the proposed mechanism of formation of the lunar surface, aerolitic or acidic materials can occur in both the maria and the terrae, while basaltic rocks would predominate in the maria. This information can be used to interpret future in situ lunar elemental analyses. If the measured elemental abundances correspond to those characteristic of acidic types of rocks, this would indicate that melting and chemical differentiation had taken place some time during lunar history. (Author Abstract)

N62-12459 Michigan U., Ann Arbor.
A LUNAR THEORY REASSERTED.
K. M. Siegel and T. B. A. Senior. Repr. from J. Research Nat. Bur. Standards, v. 66D, no. 3, May-June 1962. p. 227-229. 12 refs.
(NASA Grant NsG-4-59)

Until recently, we have not attempted to answer criticisms of our lunar theory in the belief that little is gained by a continual contest of words about what are, after all, only theories based on a limited amount of experimental data. In addition, it is probable that, in the near future, new experimental results will be obtained which will indicate with more certainty the structure and composition of the lunar surface and which will then permit a more rigorous analysis of the scattering mechanism at radar wavelengths; and this would be the logical time to assess the merits of the rival theories. There would be little point in restating our own theory were it not for the fact that some of the more recent criticisms of it are based on an incorrect appreciation both of its origins and of its main points. This is particularly apparent in the recent paper by Winter [1962]; and a brief restatement of our thesis is, therefore, necessary. (Author Abstract)

N62-12490 National Aeronautics and Space Administration, Washington, D.C.
EXPERIMENTS FOR THE UNMANNED SCIENTIFIC EXPLORATION OF THE MOON.
Newton W. Cunningham. [1961] 10 p. [For presentation at the 7th Annual Meeting of the AAS, Dallas, 1961.]
OTS: $1.10 ph, $0.80 mf.

The unmanned exploration of the moon is expected to provide answers to a great many questions concerning the history of the earth-moon system and on the origin of other bodies in our solar system. The means for obtaining these answers lie in the efficient use of a variety of scientifically instrumented spacecraft capable of probing, measuring, analyzing, and observing the properties of the lunar environment, surface and subsurface. Some of the experiments being considered for lunar rough and soft landing payloads will be discussed as well as the type of information which would be most desirable from a lunar orbiter. A brief resume of the steps necessary in the development of instrumentation for unmanned geologic investigations will also be presented. (Author Abstract)

N62-12652 National Aeronautics and Space Administration. Langley Research Center, Langley Station, Va.
IMPACT CHARACTERISTICS OF VARIOUS MATERIALS OBTAINED BY AN ACCELERATION-TIME-HISTORY TECHNIQUE APPLICABLE TO EVALUATING REMOTE TARGETS.
John Locke McCarty and Huey D. Carden. Washington, NASA, June 1962. 63 p. 15 refs.
(NASA TN D-1269) OTS: $1.75.

Projectiles were impacted on a variety of targets at relatively low impact velocities to study crater characteristics and recorded acceleration time histories. The data are presented as a function of impact velocity or of parameters composed of variables contained in available impact theories or developed from empirical analyses. The results of the study indicate that the surface penetrability or hardness of a remote target, such as the moon, can be described in terms of the penetrability of accessible earth materials by means of an acceleration-time-history technique. (Author Abstract)

N62-12797 North American Aviation, Inc., Downey, Calif.
PROCEEDINGS OF THE [ELEVENTH] LUNAR AND PLANETARY EXPLORATION COLLOQUIUM, BURBANK, CALIF., NOV. 28-29, 1961. VOL. III, NO. 1.
E. M. Fallone, ed. May 15, 1962. 89 p. refs.
CONTENTS:
1. PLANETARY ATMOSPHERES. p. 1-21. refs.
2. SOLAR PHENOMENA. p. 23-49. refs.
3. THE ATMOSPHERE OF THE MOON. p. 51-68. refs.
4. PROBLEMS OF LUNAR AND PLANETARY EXPLORATION. p. 69-79. refs.

N62-12866 National Aeronautics and Space Administration. Flight Research Center, Edwards, Calif.
CREW SAFETY AND SURVIVAL ASPECTS OF THE LUNAR-LANDING MISSION.
Hubert M. Drake. [1962?] 10 p. 4 refs. For presentation at IAS meeting on "Man's Progress in the Conquest of Space," St. Louis, Mo., Apr. 30-May 2, 1962.
OTS: $1.10 ph, $0.80 mf.

Some of the safety and survival aspects of the manned lunar-landing mission are examined. The conditions requiring abort to the earth, lunar orbit, and lunar surface are determined. Some of the possible design requirements to permit abort to lunar orbit or surface are indicated. Lunar orbital and surface survival kits are described, and the stationing of such kits in lunar orbit and at the intended landing site is proposed. (Author Abstract)

N62-12898 National Aeronautics and Space Administration. Langley Research Center, Langley Station, Va.
THE DESIGNATION OF SELENOGRAPHIC COORDINATES.
William H. Michael, Jr. [Mar. 5, 1962] 4 p. Prepared for publication in Nature. Typescript.
OTS: $1.10 ph, $0.80 mf.

Because of the confusion which exists today in the designation of selenographic coordinates, the International Astronomical Union has suggested a solution to the problem by adopting the following conventions for compiling new maps of the moon: (1) astronomical maps for purposes of telescopic observations are oriented according to astronomical practice, the South being up, and the terms East and West being deleted; (2) astronautical maps, for direct exploration purposes, are printed according to ordinary terrestrial mapping, North being up, East at the right, and West, left; and (3) altitudes and distances are given in the metric system. (V.D.S.)

N62-13341 **Grumman Aircraft Engineering Corp., Bethpage, N.Y.**
LABORATORY INVESTIGATION OF "MOON-SOILS".
John D. Halajian. N.Y., Inst. of the Aerospace Sciences [1962]. 32 p. 37 refs. Presented at the IAS National Summer Meeting, Los Angeles, June 19-22, 1962.
(IAS Paper 62-123) IAS: $0.50 members, $1.00 nonmembers.

Among the basic problems which will influence human existence and operation on the Moon, one of the least understood and recently

the most debated is the nature of the lunar surface. It is believed that some aspects of current speculation pertaining to the mechanical properties of lunar soils could be elucidated in the laboratory. Soil behavior is basically a particle surface-dependent phenomenon. The investigation of surface forces between ultra-clean soil particles, likely to be found on the Moon, is obscured by adsorbed impurities that are believed not to be released entirely under vacuum conditions hitherto achieved in the laboratory. Hence, special emphasis is given to some problems of environment simulation. No less important are problems of moon-soil simulation. These are discussed in the light of terrestrial- and lunar-soil generating mechanisms and existing but hitherto unused knowledge accumulated in the literature of allied fields. It is concluded that comminution of particles in vacuo could lead to a more realistic moon-soil sample than the difficult and questionable cleaning of earth-soils from their sorbed impurities. Predictions made on the grain size distribution of lunar soils are critically reviewed in terms of past and suggested experiments, and a coarser particle distribution is found to be more consistent with known aspects of lunar geology and environment and particle physics and surface chemistry.

(Author Abstract)

N62-13344 Grumman Aircraft Engineering Corp., Bethpage, N.Y.
METALASTIC WHEELS FOR LUNAR LOCOMOTION.
Edward G. Markow. N.Y., Inst. of the Aerospace Sciences [1962]. 23 p. 10 refs. Presented at the IAS National Summer Meeting, Los Angeles, June 19–22, 1962.
(IAS Paper 62-135) IAS: $0.50 members, $1.00 nonmembers.

This paper investigates, analytically and through model tests, locomotion techniques that can be applied to the mobility requirements of a lunar roving vehicle. After analysis of existing concepts of rigid wheel and track systems, a unique spaced-link elastic wheel system evolved. Model tests demonstrated that metal-elastic wheels offer the long footprint advantages of a track and the central hub simplicity of a rigid wheel. Using a rigid wheel of equal diameter as an index of comparison, the elastic wheel is shown to offer a 50 percent decrease in rolling resistance, a 40 percent increase in draw bar pull, and a significant increase in obstacle climbing performance. All tests and analyses use the procedures and techniques currently accepted in the land locomotion sciences. (Author Abstract)

N62-13488 National Aeronautics and Space Administration, Washington, D.C.
THE ROLE OF PROJECT RANGER IN THE NASA LUNAR PROGRAM.
Oran W. Nicks. N.Y., American Rocket Society [1961]. 6 p. American Rocket Society Space Flight Report to the Nation, New York Coliseum, Oct. 9-15, 1961.
(ARS Paper 2236-61) ARS: $0.50 members, $1.00 nonmembers.

Project Ranger is the first U.S. lunar probe designed for landing survivable payload on the moon to determine lunar characteristics. Early Ranger flights have mission objectives to (1) test the basic design and operational features of a lunar spacecraft, and (2) obtain interplanetary data with scientific instruments carried in place of the lunar capsules. Scientific experiments carried on the first Ranger spacecraft are designed to obtain information on magnetic fields, charged particles, solar X-rays, micrometeorites, and the effects of a vacuum environment on friction. The landing mission Ranger, a series of spacecraft designed for the primary objective of gaining detailed data on lunar characteristics, will consist of a bus (a basic hexagonal structure with power supplies, radios, altitude control, and midcourse guidance) and a landing capsule (a separable, survivable instrument package and its retrorocket). The landing capsule will be launched from the bus just before the bus crashes on the lunar surface; the capsule will decelerate to allow impact at a nominal speed. A vidicon camera will transmit pictures of the lunar surface during the capsule approach, so that each sequential picture will cover a decreasing area with increasing resolution. The capsule will contain a gamma ray spectrometer for determining the abundances of radioisotopes on the lunar surface and a single-axis seismometer to obtain measurements for determining the nature of the lunar surface, its interior, and its origin. (M.P.G.)

N62-13633 Rand Corp., Santa Monica, Calif.
STUDIES OF THE PHYSICAL PROPERTIES OF THE MOON AND PLANETS. Quarterly Technical Progress Report (4).
June 30, 1961. 91 p. 24 refs.
(JPL Contract N-33561(NASw-6))
(RM-2817-JPL) OTS: $8.60 ph, $2.93 mf.

The report contains factual and conjectural data of the physical properties of the moon and the planets. Included in the report are studies pertaining to a survey of the Moon's magnetic field, acceleration of plasma particles, the Martian atmosphere, the gravity field and internal structure of Mars, a suggestion for determination of wind vectors on Mars, a parametric comparison of model atmospheres of the Earth and Mars, and a survey of observational methods for observing planetary atmospheres. (P.F.E.)

N62-13661 Seismological Lab., Calif. Inst. of Tech., Pasadena.
A SEISMOMETER FOR RANGER LUNAR LANDING. Final Report.
F. E. Lehner, E. O. Witt, W. F. Miller and R. D. Gurney. May 15, 1962. 65 p. 5 refs.
(Contract NASw-81)
OTS: $6.60 ph, $2.15 mf.

Reported in this paper is the development of a seismometer for use in the Ranger series of lunar landings. The purpose of the experiment, instrument performance specifications, and philosophy of design to achieve the goals are discussed. An account is given of preliminary experiments performed, development of flight prototypes and tests to verify survival capability. A brief description is given of the data transmission and analog presentation system. (Author Abstract)

N62-13889 National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, Ala.
LUNAR STORAGE OF LIQUID PROPELLANTS.
W[illiam] E. Dempster, R. L. Evans, and J. R. Olivier. Washington, NASA, July 1962. 41 p. 4 refs.
(NASA TN D-1117) OTS: $1.00.

A geometric relationship is established between the angle of incidence of the sun's rays on the lunar surface and the lunar latitude and time angles. This relationship shows that the lunar surface temperature decreases with increasing latitude angles and that the lunar surface temperature is at its maximum at any given latitude at a time angle corresponding to noon. The surface temperature of a well-insulated liquid propellant storage tank is examined in light of this relationship. Several parameters are examined to determine their influence in controlling the tank surface temperature; namely, tank surface properties, tank geometry, and local altering of the lunar surface in the vicinity of the tank. The storage period for high-boiling-point propellants may be indefinite under proper thermal conditions, owing to the equilibrium temperature of such propellants; low-boiling-point propellants may be stored for a finite period only. The most desirable methods for maintaining these propellant classes are presented with respect to latitude location, tank geometry, etc. In conclusion, a comparison of the storage times attainable for LH_2 storage above ground and below ground shows that they can be made almost equal. On the basis of this conclusion, it is seen that factors other than heat transfer decide whether the storage tank should be buried under or situated on the lunar surface. (V.D.S.)

N62-13914 Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena.
SPACE PROGRAMS SUMMARY NO. 37-15, VOLUME VI FOR THE PERIOD MARCH 1, 1962 TO JUNE 1, 1962. SPACE EXPLORATION PROGRAMS AND SPACE SCIENCES.
June 30, 1962. 94 p. refs.
(NASA Contract NAS7-100)

(JPL Space Programs Summary 37-15, Vol. VI) OTS: $8.60 ph, $3.02 mf.

This report covers the current status of the Ranger and Surveyor projects. The Ranger Project has entered the flight stage; Surveyor is in hardware development. The objective of the Ranger Project is to exploit present technology in support of the U.S. manned lunar flight program. Nine Ranger launchings, using Atlas-Agena B rockets, are now planned. Four of these flights have been made; the next is scheduled for this year. Rangers 1 and 2 were engineering evaluation flights to test the basic system to be employed in later lunar and planetary vehicles. Several scientific experiments were carried out, but on a noninterference basis. The Ranger 3, 4, and 5 spacecraft carry a gamma-ray instrument, a radar reflection experiment, a TV camera, and a rough-landing seismometer capsule. The 1963 flights (beginning with Ranger 6) will carry a high-resolution TV package and additional radiation experiments. The objective of the Surveyor Project is to take the next step in advancing lunar technology, by making reconnaissance surveys from lunar orbit and controlled soft landings on the Moon. Seven flights using Centaur launch vehicles are now planned. Surveyor spacecraft, being designed and built by the Hughes Aircraft Company under JPL subcontract, will carry a variety of instruments, including TV cameras, radiation environment monitors, and geophysical equipment for determining characteristics of the lunar surface.

(P.F.E.)

N62-14085 Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena.

DYNAMIC PENETRATION STUDIES IN CRUSHED ROCK UNDER ATMOSPHERIC AND VACUUM CONDITIONS.

David J. Roddy, John B. Rittenhouse, and Ronald F. Scott. Apr. 6, 1962. 19 p. 8 refs.

(Contract NAS7-100)

(JPL-TR-32-242) OTS: $1.60 ph, $0.80 mf.

A device was constructed to study dynamic penetration in crushed rock in high-vacuum (10^{-5} mm Hg) conditions. The apparatus was designed to drop cylindrical, metal rods, pointed on one end, into cohesionless crushed rock material. Dynamic penetration was studied as a function of several particle sizes and mixtures of these particle sizes. Other factors considered were the density of packing, probe dimensions, vacuum pressure, and vacuum degassing rates. Experimental results show that the density of packing of the crushed rock particles is the dominant factor affecting the dynamic penetration. The maximum penetration occurs in air in the crushed rock with low density packing. The minimum penetration occurs in air in densely packed material. Dynamic penetration in vacuum for the low-density and high-density packing lies between the results of penetration in air for the same packing conditions. At vacuum pressures above approximately 0.1 mm Hg, all penetration values approach the air penetration measurements.

(Author Abstract)

N62-14197 School of Aerospace Medicine, Aerospace Medical Div., Brooks AFB, Tex.

LECTURES IN AEROSPACE MEDICINE, [HELD AT SCHOOL OF AEROSPACE MEDICINE] 8-12 JANUARY 1962.

[1962] 419 p. refs.

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19. SOIL-LESS GARDENING ON THE MOON. Hans G. Clamann. p. 369-384. (See N62-14216 12-16)
20. THE LUNAR CRUST FOR LIFE SUPPORT. Jack Green. p. 385-432. (See N62-14217 12-16)
21. WHO OWNS THE MOON? Thomas A. Taggart. p. 433-446. (See N62-14218 12-16)

N62-14214 School of Aerospace Medicine, Aerospace Medical Div., Brooks AFB, Tex.

MONITORING OF MOON BASE ATMOSPHERES BY GAS CHROMATOGRAPHY.

Thomas B. Weber. *In its* Lectures in Aerospace Medicine, 1962. p. 327-346. (See N62-14197 12-16)

Gas chromatography has been used to separate, detect and quantitate the atmospheric components at atmospheric and lower pressures in the two-man space cabin simulator. A two column gas chromatograph using molecular sieve and silica gel adsorbents measured oxygen supply, ascertained carbon dioxide and carbon monoxide levels, and measured humidity and inert gases. In addition, three multipurpose adsorbents are available for chromatographic detection of a diverse group of volatiles that are or might soon become obnoxious, noxious, toxic or even lethal. These durable columns can be incorporated into a single package that could withstand the rigors of a lunar trip and, after arrival, could be expected to perform continuous atmospheric monitoring for extended periods at a lunar base.

(M.P.G.)

N62-14215 Air U., Maxwell AFB, Ala.

THE ECOLOGIC PROFILE OF THE MOON.

Hubertus Strughold. *In* School of Aerospace Medicine. Lectures in Aerospace Medicine, 1962. p. 347-368. 16 refs. (See N62-14197 12-16)

Ecological considerations pertaining to their implications for a terrestrial visitor to the moon are presented. Since the moon has little, if any, atmosphere, the lunar environment is essentially a vacuum exposed to the full spectrum and intensity of solar radiations with accompanying acoustic, visual, thermal, and physiologic problems. Most of the physical conditions lie ecologically below the minimum or

above the maximum human tolerance levels. Lunar life for terrestrials will in all probability be a sophisticated cave life in underground installations which will provide some thermal stability and shielding from meteorites and cosmic rays. The challenge to space medicine and bioastronautics is to artifically create an ecological optimum for lunar exploration. (M.P.G.)

N62-14216 School of Aerospace Medicine, Aerospace Medical Div., Brooks AFB, Tex.

SOIL-LESS GARDENING ON THE MOON.

Hans G. Clamann. *In its* Lectures in Aerospace Medicine, 1962. p. 369-384. 8 refs. (See N62-14197 12-16).

Raising vegetables in hydroponic cultures on the moon seems possible. One requirement is controlling and filtering the sunlight before it enters the hydroponium because of the deleterious effect of ultraviolet and infrared lights upon growth. Another requirement consists of creating a suitable artificial illumination. Recent botanic investigations seem to indicate that plant hormones can be utilized to stimulate growth in certain phases of plant development. Since it has been found that green leaves show the highest amount of protein and chlorophyl in early stages of their development, early harvesting may be more economical on the moon than it would be on earth. However, many problems remain to be solved before the first home-grown lunar harvest. (Author Abstract)

N62-14217 North American Aviation, Inc. Space Sciences Lab., Downey, Calif.

THE LUNAR CRUST FOR LIFE SUPPORT.

Jack Green. *In* School of Aerospace Medicine. Lectures in Aerospace Medicine, 1962. p. 385-432. (See N62-14197 12-16)

An analysis of lunar topography is given to establish the presence of volcanism on the moon. The life support possibilities of the moon are shown to be greatest in the volcanic areas because they offer more protection, more minerals, and more warmth than anywhere else on the moon. The geochemical and geophysical prospecting devices of the pretroleum industry are directly applicable to seeking out rocks, minerals and thermal sources on the moon. The possible applications of the likeliest volcanic materials (sulfur, pumice, volcanic ash and volcanic rock) as well as the cosmic infall material are explored to determine a possible lunar base technology. The availability of protective terrain and raw materials will be one of the factors to be considered in selecting the lunar base site. (M.P.G.)

N62-14427 California U., La Jolla. School of Science and Engineering.

THE ORIGIN AND NATURE OF THE MOON.

Harold C. Urey. Repr. from Smithsonian Report for 1960, p. 251-265. 11 refs.

(NASA Grants NsG-97-60 and NsG-98-60)

(Smithsonian Institution. Publication 4437)

To gain a better understanding of the origin and nature of the Moon, the physical features of the lunar surface are reviewed. The material studied includes the following: the origin of the craters; the shape of the Moon; the Imbrian collision; the time of occurrence of craters and Imbrian collision; composition of the maria; duration of the meteorite bombardments; and the other hemisphere of the moon. (J.R.C.)

N62-14433 Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena.

PROGRESS REPORT ON RANGER.

James D. Burke. N.Y., American Rocket Society, 1962. 8 p. Presented at the ARS Lunar Missions Meeting, Cleveland, Ohio, July 17-19, 1962.

(ARS Paper 2493-62) ARS: $0.50 members, $1.00 nonmembers.

History and future plans of the whole Ranger project are reviewed. Scientific objectives are to find out what the Moon is like and why it is that way. Findings from a few isolated observations will assist in the development of a complete lunar model for Apollo. A secondary objective is to survey the interplanetary medium enroute. Four Rangers have been launched with a variety of difficulties plaguing each flight. However, much operating and design data were obtained. Ranger III and its Agena vehicle are now in heliocentric orbits with periods of about 395 days. Ranger IV made impact on the far side of the Moon after a 64-hour flight. There will be one more Ranger flight during 1962, and the four remaining will be launched in 1963. (P.F.E.)

N62-14434 Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena.

MAN-TO-THE-MOON AND RETURN MISSION UTILIZING LUNAR-SURFACE RENDEZVOUS.

John Small and Walter J. Downhower. N.Y., Am. Rocket Society, [1962] 20 p. Presented at the ARS Lunar Missions Meeting, Cleveland, July 17-19, 1962.

(NASA Contract NAS7-100)

(ARS Paper 2479-62) ARS: $0.50 members, $1.00 nonmembers.

This paper presents a study on the use of a lunar-surface rendezvous technique. Advantages of this technique include: Use of the moon itself as a space station or assembly area which permits use of known lunar conditions for design criteria (no weightlessness problems); reduction of critical dependence of mission capability on decisions relating to launching vehicle design and development; opportunity to commence parallel efforts on all system elements now, without dependence on the capability of injecting large weights into earth-orbit or escape trajectories; simulated automatic lunar assembly and check-out operations; and stockpiling materials and testing and check-out of return system before the manned portion of the mission is carried out. In terms of growth potential, the lunar-surface rendezvous concept is attractive because it offers early development of techniques required by advanced missions. Extensive manned lunar exploration and the establishment of a lunar base or scientific station require the ability to perform lunar-surface operations, including the rendezvous of payloads on the Moon and the construction and maintenance of long-life lunar facilities. Results of the study include: (1) development of a system concept for a manned landing and return mission; (2) functional description and weight estimates of system elements using a Saturn launching vehicle with an estimated 30,000-lb lunar-injection capability; (3) operational sequence for the mission; (4) variations for a three-man mission and a minimum one-man mission; (5) examination of lunar landing accuracy and lunar surface operations; and (6) review of a program leading up to the manned lunar-landing and return mission. (P.F.E.)

N62-14439 Aeronautical Chart and Information Center, St. Louis, Mo.

USAF CARTOGRAPHIC SUPPORT OF LUNAR MISSIONS.

Robert W. Carder. N.Y., Am. Rocket Society, 1962. 18 p. 1 ref. Presented at the ARS Lunar Missions Meeting, Cleveland, July 17-19, 1962.

(ARS Paper 2474-62) ARS: $0.50 members, $1.00 nonmembers.

The United States Air Force is publishing a series of photographic and cartographic products of the moon. A Lunar Atlas containing a comprehensive selection of lunar photography has been published, followed by several supplements. USAF Lunar Mosaics in several sizes are now available and a series of Lunar Aeronautical Charts, Scale 1:1,000,000, sheet size 22 × 29 inches are under construction. These charts, lithographed in four colors, contain 300 meter contours. This program is being accomplished jointly by the Air Force Cambridge Research Laboratory and the Aeronautical Chart and Information Center in collaboration with the scientific community.

(Author Abstract)

N62-14445 Astro-Electronics Div., Radio Corp. of America, Princeton, N.J.

A LUNAR SURFACE MODEL FOR ENGINEERING PURPOSES.

Victor P. Head. N.Y., Am. Rocket Society, 1962. 14 p. 22 refs. Presented at the ARS Lunar Missions Meeting, Cleveland, July 17-19, 1962.

(ARS Paper 2475-62) ARS: $0.50 members, $1.00 nonmembers.

Subresolution surface geometry and soil strength of the lunar maria are deduced using evidence from several disciplines. Contiguous and overlapping craterlets in sintered granular rock of strength proportional to depth are predicted for the least formidable areas, and demonstrated by table-top models of the lunar surface and by statistical and thermo-mechanical studies. Scale factors required for dynamic model testing of a lunar surface mechanism at earth gravity are derived and tabulated, with consideration for the interaction between model mechanism and environmental model terrain. Vigorous pursuit of engineering interpretations of thermal, photometric, radar-echo, and radar-penetration evidence is shown to be well worthwhile, and close-up visual observation and soil penetration experiments are urged, as vital precursors to the manned lunar mission.

(Author Abstract)

N62-14457 General Motors Corp. Defense Systems Div., Santa Barbara, Calif.

A STUDY OF THE PHENOMENA OF IMPACT AND ITS RELATION TO THE REACTION OF THE LUNAR SURFACE TO THE IMPACT OF A LUNAR PROBE.

J. William Gehring and David W. Sieck. N.Y., Am. Rocket Society, 1962. 13 p. 19 refs. Presented at the ARS Lunar Missions Meeting, Cleveland, July 17-19, 1962.

(ARS Paper 2476-62) ARS: $0.50 members, $1.00 nonmembers.

This paper describes the preliminary results of an experimental investigation to evaluate the physical phenomena associated with the impact of a lunar probe on the surface of the moon. In view of the tasks proposed by NASA for the future Surveyor and Prospector series of vehicles, it is of utmost importance to learn as much as possible about the lunar surface from the impact of the earlier Ranger Vehicle tests. The experimental program consisted of a parametric study involving the variables associated with the impacting projectile versus targets designed to simulate the lunar surface. The tests consisted in firing projectiles of varied mass, material, and velocity into a variety of target materials. Observations were made and quantitative data were obtained for the magnitude of the luminosity of the impact flash, the duration of the flash, and the spectrum of emitted light. Also, high-speed optical pictures were made to determine the disposition of the impacting projectile and the debris ejected from the resultant crater. From the analysis of the experimental data, it is possible to make an estimate of the impact flash likely to be observed on impact of a lunar probe on the moon's surface. (Author Abstract)

N62-14459 Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena.

INTERNAL STRUCTURE OF THE MOON.

Zdeněk Kopal. N.Y., Am. Rocket Society, 1962. 19 p. 45 refs. Presented at the ARS Lunar Missions Meeting, Cleveland, July 17-19, 1962.

(ARS Paper 2455-62) ARS: $0.50 members, $1.00 nonmembers.

From a survey of the present knowledge bearing on the internal structure of the Moon, these conclusions are drawn: The relatively low mean density of the lunar globe suggests that the Moon is approximately of the same composition as the terrestrial mantle, but is either deficient in iron, nor enriched with some common low-density substance (such as H_2O or C_2). The mass of the Moon is in a state very close to hydrostatic equilibrium, but deviations from it (as inferred from the motion of the Moon) are significant. In particular, the observed libration of the Moon is definitely inconsistent with an assumption that its form is one of equilibrium under forces prevailing at any distance from the Earth. The crust of the Moon cannot sustain largescale differences in level of more than 1 km; and the apparent absence of free physical libration reveals that the degree of rigidity of the lunar globe must be considerably less than that of the Earth. Radiogenic heat produced by a spontaneous decay of long-lived radioactive elements should have raised the present temperature of the bulk of the lunar mass to at least 1000° K even if the Moon originated as an initially cold body. Moreover, this temperature should at present still be increasing. The conductive temperature gradient created by radiogenic heating exceeds the adiabatic gradient of molten rocks by a factor of 10 to 100 in most parts of the interior, rendering it almost certain that slow convection currents will provide at least as effective means of outward heat transport as conduction or radiation. Theoretical considerations indicate, moreover, that stable convection flow can develop only for patterns characterized by spherical-harmonic symmetry of very high order. This flow is probably the main cause why the distribution of mass inside the Moon deviates from hydrostatic equilibrium, as evidenced by the motion of the Moon. The observed disparity in distribution of the lunar maria between the near and far side of the Moon is also likely to be due to this cause. Should the newly formed Moon have contained a sufficient proportion of short-lived radioactive elements to melt it completely in the first 10 million years of its existence, convective cooling would have been capable to bring about solidification in a comparable period of time. The secular heating should, moreover, have been accompanied by a gradual escape of volatile elements or compounds from the interior; and observable surface manifestations of such processes are briefly discussed. (Author Abstract)

N62-14641 Stanford Research Inst., Menlo Park, Calif.

EVALUATION OF INFRARED SPECTROPHOTOMETRY FOR COMPOSITIONAL ANALYSIS OF LUNAR AND PLANETARY SOILS. Interim Report No. 1, [Jan. 1 to May 15, 1962].

R. J. P. Lyon. May 25, 1962. 31 p.

(NASA Contract NASr-49(04); SRI Project PSU-3943)

OTS: $3.60 ph, $1.13 mf.

Characteristic spectral absorption peaks for various minerals are being determined and analyzed, because of the possibility that the analyses can serve as the basis for instrumentation on lunar surface vehicles (Surveyor) or on orbiting spacecraft (Ranger). The instrumentation would use the reflected or emissive infrared radiation for compositional analyses of lunar soil. Qualitative analyses of purified single minerals (mainly silicates) have been performed spectrophotometrically in the region from 4000 cm^{-1} to 400 cm^{-1}, using both the NaCl and KBr prism optical regions. The spectra of mixtures of minerals were found to be additive, so characteristic absorbance peaks may be distinguished even when mineral percentages in the rock are small. Quantitation of specific mineral content is accomplished by placing reproducible quantities of the mineral in the infrared beam and plotting the absorbance values of the spectra obtained against concentrations of the mineral Anion absorptions are indicative of chemical composition. Inorganic anions have strong simple absorption peaks; a strong absorption within one of these spectral bands implies that a given functional anion group is present. The wavelength of this strong peak or of smaller peaks will indicate to which metal cation the group is bonded. Intermediate values for the principal absorbances are diagnostic of solid solutions. Typical results for silicate mineral groups are presented. (M.P.G.)

N62-14775 Center for Radiophysics and Space Research, Cornell U., Ithaca, N.Y.

SECOND PRELIMINARY REPORT ON EXPERIMENTS RELATING TO THE LUNAR SURFACE: 1. PHOTOMETRIC STUDIES. 2. PROTON BOMBARDMENT OF MINERALS.

Bruce W. Hapke. July 1, 1962. 65 p. 17 refs.

(NASA Grant NsG 119-61)

(CRSR-127) OTS: $6.60 ph, $2.15 mf.

Preliminary results of two experiments relating to the nature of the lunar surface are described. These experiments are photometric studies of surfaces and proton bombardment of minerals. To scatter light in the same manner as the moon a surface must be extremely intricate. Surfaces of solid rocks, slag or coarsely-ground rock powders are not sufficiently complex. However, when the particle size of the pulverized rock decreases below about 20 microns in the

laboratory these particles build extremely intricate surfaces which are capable of backscattering light strongly. An upper limit to particles which compose the outermost layers of the moon is estimated to be 50μ, with 10μ being more probable. In order to backscatter light the particles must be nearly opaque.

The effects of proton bombardment depends on the chemical constitution of the irradiated mineral. Metallic Fe and Ag were reduced from Fe_2O_3 and Ag_2S respectively, while Al_2O_3, MgO and SiO_2 were largely unaffected by 10 kev protons. No welding or sintering of the mineral powders was observed. (Author Abstract)

N62-15115 Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena.
LUNAR SEISMOLOGY.
R. L. Kovach and F. Press. Aug. 10, 1962. 15 p. 19 refs.
(NASA Contracts NAS7-100 and NASw-81)
(JPL-TR-32-328) OTS: $1.60 ph, $0.80 mf.

A knowledge of the seismicity of the Moon will provide an insight into its thermal and tectonic history. Analyses of lunar seismograms from a simple passive experiment should give an estimate of the composition of the Moon and indicate its main internal structural features, such as the presence of a lunar crust and core. Meteor impacts will most probably be recorded by a lunar seismograph, even though the task of distinguishing such impacts from natural moonquakes may prove to be difficult. A single-axis seismometer will be carried aboard *Ranger 5*, and the data from any lunar seismic disturbances will be telemetered to Earth for subsequent analyses. More sophisticated active seismic experiments can contribute important information on the regional and local variations in the internal structure of the Moon and should rank high in priority for future lunar missions. (Author Abstract)

N62-15117 Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena.
THE LUNAR SEISMOGRAPH EXPERIMENT: RANGER 3, 4, 5.
D. F. Adamski. June 1, 1962. 41 p. 8 refs.
(NASA Contract NAS7-100)
(JPL-TR-32-272) OTS: $4.60 ph, $1.43 mf.

This report presents a description of the lunar seismograph experiment carried aboard *Rangers 3, 4* and *5*—the first spacecraft capable of landing operating instrument packages on the Moon's surface. The seismometer (seismic transducer) is described along with its environmental testing, its sterilization, and its integration in a lunar impact capsule as well as the data processing system used and the form in which data will be presented to the seismologists.
(Author Abstract)

N62-15123 National Aeronautics and Space Administration. Langley Research Center, Langley Station, Va.
SELECTED ARTICLES ON LIGHT SCATTERING AND PHOTOMETRIC RELIEF OF THE LUNAR SURFACE.
N. S. Orlova (Leningrad U.). Washington, NASA, Sept. 1962. 22 p. 15 refs. Transl. by Nickolai Charczenko of "Indikatrissa rasseyaniya dlya lunnoy poverkhnosti", Astron. Tsirkuliar Akad. Nauk SSSR (Kazan), no. 156, 1955. p. 19-21. and "Fotometricheskiy rel'yef lunnoy poverkhnosti", Astron. Zhur. Akad. Nauk SSSR (Moscow), v. 33, no. 1, 1956. p. 93-100.
(NASA TT F-75) OTS: $0.50.

CONTENTS:
1. DIAGRAMS OF LIGHT SCATTERING FOR THE LUNAR SURFACE. N. S. Orlova. p. 1-4. 3 refs.
2. PHOTOMETRIC RELIEF OF THE LUNAR SURFACE. N. S. Orlova. p. 5-17. 12 refs.

N62-15331 Committee on Space Research (COSPAR), The Hague (Netherlands).
SOME RESULTS OF THE MOON EXPLORATION BY RADIOPHYSICAL METHODS.
V. S. Troitski (Gorky N. I. Lobachevsky State U.). [1962] 15 p. 17 refs. Presented at Third International Space Science Symposium and Fifth COSPAR Plenary Meeting, Washington, Apr. 30 to May 9, 1962. Meeting cosponsored by NASA.

Results about the nature, thermal regime, and the structure of lunar surface obtained by investigating lunar radio emission are presented. The studies were directed to reveal if there is a strong nonuniformity of the surface layer. It was found out by measurements at the 3.2 cm range in 1952 to 1955 that the thickness of radiating layer is practically proportional to the received wave. Hence, by carrying out the measurements of radiation in a large wave band one can explore the upper layer at different depths and determine if there is a sharp change of layer properties by comparison of the character of radiation change at the different exploring waves. The measurement accuracy of absolute values of lunar radio temperatures was not higher than $\pm 15\%$ and therefore cannot be used for obtaining definite conclusions. The low magnitude of Σ that is determined according to the surface effect (emissivity) may be correlated with a strong surface roughness that is compared with the wavelength when the material is sufficiently dense. The surface thermal parameters determined from radiation data are accurate to within $\pm 5\%$. It is possible to determine the density and structure of the upper layer rocks from the thermal parameters. The obtained accurate data of the moon temperature at different wavelengths point out the possible existence of a thermal flux from underneath the lunar surface and that temperature increases in the center of the moon. (J.R.C.)

N62-15502 National Aeronautics and Space Administration. Goddard Inst. for Space Studies, New York, N.Y.
AMERICAN PLANS FOR EXPLORING THE MOON WITH INSTRUMENTS.
Robert Jastrow. Repr. from New Scientist (London), v. 10. p. 702-705.

Exploration of the Moon will begin with the landing of unmanned instrument packages prior to manned landings. The *Ranger* spacecraft is scheduled to carry comparatively simple instruments, such as a seismometer, to the Moon's surface in the next year or two. Later experiments to precede manned exploration may include the return of samples of lunar matter to Earth and the deposit of remote-controlled mobile vehicles capable of sampling the composition of the surface over a large area around the landing sites. (R.C.M.)

N62-15621 Manchester U. (Gt. Brit.)
A "SEEING MONITOR" FOR ASTRONOMICAL PHOTOGRAPHY. Technical Note No. 1.
R. F. Edgar. Apr. 6, 1962. 44 p. 6 refs.
(Contract AF 61(052)-400)
(AFCRL-62-818)

This report considers the principles of several types of apparatus to monitor seeing conditions and to select favorable moments for taking photographs of the moon. (Author Abstract)

N62-15742 Kyoto U. Inst. of Astrophysics (Japan).
A GEOLOGICAL INTERPRETATION OF THE LUNAR SURFACE.
S. Miyamoto. 1960. Repr. from J. Intern. Lunar Soc., July 1959. 9 p. 5 refs.
(Kyoto U. Inst. of Astrophys. and Kwasan Obs. Contrib. no 90, p. 174-182)

The origin of the lunar maria is ascribed to the differentiation of the light-colored, lightweight silicic mass from the dark and heavy basaltic mass, as in our earth. This hypothesis was compared with the current idea that the maria were formed by lava inundation following the subsidence. Difficulties with the lava inundation theory are presented. These can be explained by the interpretation of the surface features based upon the differentiation hypothesis. The explosive nature of silicic mass and the fluidity of quiescent basaltic mass are shown to account for the different aspects of the various lunar continents and marias. (Author Abstract)

N62-15743 Kyoto U. Inst. of Astrophysics (Japan).
PHOTOGRAPHIC ATLAS OF THE MOON.
S. Miyamoto and M. Matsui. 1960. 82 p.
(Kyoto U. Inst. of Astrophys. and Kwasan Obs. Contrib. no. 95)

The Atlas contains 85 photographs of the Moon taken from 1958 to 1960. A Cooke refractor with an aperture of 30 cm and f/15 was used. The aperture was reduced to 22.5 cm to get the best image. A reflex camera with focal plane shutter was used with a Walz YA 2 orange filter. The image of the Moon was enlarged with the Kellner eyepiece of focal length of 40 mm that is attached in front of the camera. The photographs are arranged beginning from the western part of the moon to the eastern regions. The H. P. Wilkins lunar map is recommended for correlation between photographs and the map. (P.F.E.)

N62-15744 Kyoto U. Inst. of Astrophysics (Japan).
MAGMATIC BOILING AND UNDERGROUND STRUCTURE OF THE MOON.
S. Miyamoto. 1960. 7 p. 9 refs.
(Kyoto U. Inst. of Astrophys. and Kwasan Obs. Contrib. no. 96, p. 183-189)

Evidence is presented that the lunar craters are formed as the traces of degassing processes at the time of crustal formation by cooling. After the lunar crust was formed, the underground magmas boiled by further cooling and formed underground caverns filled with volatile constituents. This phenomenon is known in petrology as the second boiling. Occasional appearance of haze and gas ejection from lunar craters is attributed to the leakage of gases from such underground caverns. (Author Abstract)

N62-16002 Geophysics Corp. of America, Bedford, Mass.
LUNAR SURFACE STUDIES BY ULTRAVIOLET TECHNIQUES.
F. F. Marmo and J. Sullivan. *In its* Planetary Atmosphere Studies VIII: ... Final Report. Dec. 1961. 22 p. 7 refs. (See N62-16000 16-28)
(NASA Contract NASw-124)

The problem of optically determining the nature of the lunar surface is discussed to outline an experimental program which will provide data necessary for lunar landings. These data can best be obtained by studying the variation with wavelength and angle of incidence of selective reflectivity, polarization, and luminescence in the spectral region below 3000 Å. Since the presence of the earth atmosphere precludes ground-based investigations in this region, rocket and satellite-borne optical gear must be used for these measurements. The field data thus obtained should be correlated to data obtained from laboratory vacuum ultraviolet studies. These new data should then form the basis of some of the important decisions required for the Ranger, Surveyor, Prospector, and Man-on-the-Moon projects. (R.C.M.)

N62-16119 Joint Publications Research Service, Washington, D.C.
ROLE OF RADIO ELECTRONICS IN SOVIET SPACE EXPLORATION.
Geza Sarkozy. Sept. 25, 1962. 12 p. Transl. of article in Hiradastech. (Budapest), v. 13, no. 2, 1962. p. 70-74.
(JPRS-15430) OTS: $1.60.

Literature published on the radio electronics equipment installed in Soviet space vehicles is reviewed to outline the design principles that have been applied for precise orbiting and attainment of target trajectory. The great degree of precision is obtained by automatic components combined with radio electronics. Radio communications is also important in space flight, since command signals must be forwarded to the space ship, and the data of the various onboard measuring instruments must be reported to earth via radio. Onboard equipment is controlled by remote command signals transmitted on a radio channel; an example is given of the transmission of 16 command signals, using four frequencies on a single channel. The command installation consists of a control panel, an encoder, sound frequency generators, and a transmitter; while the onboard equipment consists of a receiver, filters, rectifiers, decoder signal receivers, decoders, and actuating units. The data acquired upon command by the onboard measuring equipment is generated into signals which pass through a circuit commutator and are fed in sequence into a telemetry signal-formulating unit. The formed signals pass to a memory unit which stores them until a signal for their transmission is received from the earth station. Synchronization of the onboard and earth circuit commutators is accomplished by synchronizing impulses transmitted on the radio band of the telemetry installation. Advanced applications included the transmission of the television camera signals from the rocket which photographed the back of the Moon; determination of the actual orbit of the Venus satellite when it was 100,000 km from the earth; radiolocation of the precise distance of Venus; and determination of the precise astronomical unit. The most advanced spacecraft permitted astronaut conversations by using bidirectional telescript and telephone connections functioning on two wavelengths, a tape recorder, and a portable radio transmitter. (M.P.G.)

N62-16180 Aerospace Information Div., Washington, D.C.
HYPSOMETRIC MAP OF THE MOON.
Sept. 6, 1962. 3 p. Review of: V. B. Neyman. On the nature of the basic lunar formations. Vsesoyuznoye astronomo-geodezicheskoye obshchestvo, Byull. no. 30 (37), 1962. p. 28-32.
(AID 62-123) OTS: $1.10 ph, $0.80 mf.

A hypsometric map of the visible side of the moon, as well as a curve depicting the frequency of occurrence of elevations and depressions, has been constructed. The map shows the situation on the moon with respect to the polar areas to be analogous to the situation obtaining on the earth. The graph showing the occurrence of heights and depths is compared with one representing the same phenomenon on earth. The lunar curve is seen to resemble the half of the terrestrial curve representative of the oceanic area. Based on Barabashov's data, the lunar formations are related to terrestrial basic rocks (continents) and ultrabasic rocks (seas). The graph of the lunar heights and depths is then compared with a profile of the floor of the Pacific ocean, and the basic formations of the lunar surface are seen to correspond to those of the terrestrial ocean floor. In both comparisons, rocks of an intermediate type are absent. An interpretative comment states that the hypsometric map and the graph of lunar heights and depths are sound contributions to lunar cartography, but that the rock comparisons must be considered as speculation until the precise nature of the lunar surface is known. (M.P.G.)

N62-16189 Aerospace Information Div., Washington, D.C.
LUNAR SURFACE FORMATIONS.
Sept. 4, 1962. 2 p. Review of: M. M. Shemyakin. On some patterns in the distribution of crater chains in the regions of Clavius and Hipparchus cirques. Vsesoyuznoye Astronomo-Geodezicheskoye Obshchestvo. Byull. no. 30 (37), 1962. p. 33-38.
(AID-62-121) OTS: $1.10 ph, $0.80 mf.

Definite geometric patterns have been detected in the distribution of parasitic crater chains in the area of Clavius and Hipparchus cirques, which indicate that the crater chains are of a single genetic origin. In the case of Clavius, a series of craters is seen to form a spiral along the floor of the cirque. These craters decrease in size progressively as the distance between them decreases. The diameters of the successive craters proceeding upward from the floor of the cirques increase in an approximate geometric progression. In the case of Hipparchus, there are two chains of craters lying along a single circumference. In both cases, the larger craters are manifestly older than the smaller ones. If the craters in each chain are interrelated, and were formed as the result of a single process, then this process must have taken place over a long period of time. The conclusion is that the patterns of younger craters could have been caused only by endogenic forces. (M.P.G.)

N62-16363 Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena.
RESEARCH SUMMARY NO. 36-12, VOLUME I FOR THE PERIOD OCTOBER 1, 1961 TO DECEMBER 1, 1961.
Jan. 2, 1962. 140 p. 129 refs.
(NASA Contract NAS7-100)
(JPL-RS-36-12, Vol. 1) OTS: $10.50 ph, $4.40 mf.

This research summary covers the following: space sciences, systems analysis, guidance and control, telecommunications, physical sciences, engineering mechanics, engineering facilities, and propulsion. (J.R.C.)

N62-16369 Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena.
THERMAL HISTORY OF THE MOON AND OF THE TERRESTRIAL PLANETS: CONVECTION IN PLANETARY INTERIORS.
Zdeněk Kopal. Apr. 30, 1962. 49 p. 22 refs.
(NASA Contract NAS7-100)
(JPL-TR-32-276) OTS: $4.60 ph, $1.67 mf.

Arguments are presented as to why the bulk of the mass in the interiors of the Moon or the terrestrial planets should be expected to be in convective equilibrium. It is shown that the conductive temperature gradient due to radiogenic heating is likely to be superadiabatic by one or two orders of magnitude, and that the rigidity as well as the viscosity of the rocks is insufficient to withstand this gradient for periods of time much longer than 10^3 years—thus giving way to convective viscous flow. Equations of the problem are set up for the most general type of the energy transfer, the requisite boundary conditions are stated, and the respective equations are linearized and reduced to tractable forms. An account is made of a particular solution of linearized equations in a homogeneous conducting configuration, in which the density changes are invoked by the changes of temperature alone. An application of this theory to the Earth's mantle reveals that such convection can indeed account for the observed coefficients of odd harmonics in the gravitational field of the Earth (as deduced from the secular perturbations of artificial satellite) for velocities of convection of one cm/year or less; but the stability of such a flow would (for commonly accepted values of the viscosity of the terrestrial rocks) require a considerable reduction in the accepted estimates of the rate of radiogenic heat liberation, or a somewhat smaller increase in the adopted coefficient of heat conduction. (Author Abstract)

N62-16389 Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena.
THERMAL HISTORY OF THE MOON AND OF THE TERRESTRIAL PLANETS.
Zdeněk Kopal. May 1, 1961. 28 p. 22 refs.
(NASA Contract NASw-6)
(JPL-TR-32-108) OTS: $2.60 ph, $1.04 mf.

The purpose of this report is to set up and solve the equations governing the thermal state and stress history of celestial bodies with a mass of the order of magnitude of that of the Moon or smaller terrestrial planets (Mercury, Mars), containing a similar proportion of radioactive elements as the chondritic meteorites. Both conductive and radiative heat transfer are considered on the basis of exact equations representing the conservation of energy. In the case of conductive heat transfer, the equations are linear and admit of analytical solutions for an arbitrary initial temperature or distribution of heat sources; for radiative heat transfer, they are nonlinear, thus, numerical integrations represent the only workable method of solution. Whenever the internal temperature exceeds the melting point of the constituent rocks, the superadiabatic temperature gradient gives rise to convection which will also transport heat. Thermal expansion of a solid body (or mantle) will again absorb energy and subtract heat from the interior; should it exceed the elastic strength of the rocks, it may lead to a large-scale cracking of the crust. An adequate description of the convection or expansion phenomena is not possible, however, within the framework of a linear theory, and again numerical integrations represent the only avenue of approach. (Author Abstract)

N62-16392 California Inst. of Tech., Pasadena.
NEW APPLICATIONS OF LUNAR SHADOW STUDIES.
Howard Pohn, Bruce C. Murray, and Harrison Brown. Repr. from Publ. Astron. Soc. Pacific, v. 74, no. 437, Apr. 1962. p. 93-105. 14 refs. Presented at the Los Angeles Meeting of the Astron. Soc. of the Pacific, June 12-14, 1961.
(NASA Grant NsG-56-60)

Important topographic information can be obtained from the variation of percentage of shaded area in a region with changing elevation of the sun. Objects of positive topographic relief generate significantly different curves than do those of negative relief. Although such curves do not bear a unique relationship to topography, a rough estimate of the relative amounts of positive and negative topography can be made and, a minimum value of the maximum slopes in the area can be determined. The shadow variation concept may also help to explain the lunar phase law. Specific data determined in this study are: (1) about 0.5% of the total lunar surface is in permanent shade and (2) both Piton and Mösting exhibit slopes in excess of 30° and of area extent well above minimum photographic resolution; about 1% of the upland area in the vicinity of the crater Argelander exhibits a comparable roughness. (Author Abstract)

N62-16447 Space Sciences Lab., General Electric Co., Philadelphia, Pa.
PLANETARY ATMOSPHERES AND RELATED INFORMATION; A SUPPLEMENTARY BIBLIOGRAPHY TO R61SD126, Oct. 1961-Aug. 1962.
E. Colabrese. Aug. 1962. 46 p. 110 refs.
(R62SD85)

N62-16618 Arizona U. Lunar and Planetary Lab., Tucson.
COMMUNICATIONS OF THE LUNAR AND PLANETARY LABORATORY, VOLUME I, NUMBERS 7-10.
Gerard P. Kuiper and Barbara Middlehurst, eds., et al. 1962. 32 p. 17 refs.
(NASA Grant NsG-161-61)

CONTENTS:
- No. 7. ON THE SPECTRUM OF LIGHTNING IN THE ATMOSPHERE OF VENUS. A. B. Meinel and D. T. Hoxie. 6 p. 16 refs.
- No. 8. ON THE PROBLEMS OF SELENODETIC PHOTOGRAMMETRY. D. W. G. Arthur. Dec. 8, 1961. 4 p.
- No. 9. PRELIMINARY DRAWINGS OF LUNAR LIMB AREAS, II. Alika K. Herring. Apr. 13, 1962. 9 p.
- No. 10. TOPOCENTRIC LIBRATIONS OF THE YERKES LUNAR PHOTOGRAPHS. Jan. 16, 1962. D. W. G. Arthur and C. S. Huzzen. 10 p.

N62-16619 Arizona U. Lunar and Planetary Lab., Tucson.
COMMUNICATIONS OF THE LUNAR AND PLANETARY LABORATORY. VOLUME I, NUMBERS 12-13.
Gerard P. Kuiper and Barbara Middlehurst, eds., et al. 1962. 131 p. 17 refs.
(NASA Grant NsG-161-61)

CONTENTS:
- No. 12. CONCENTRIC STRUCTURES SURROUNDING LUNAR BASINS. W. K. Hartmann and G. P. Kuiper. June 20, 1962. 103 p. 9 refs.
- No. 13. EVALUATION OF THE RUSSIAN PHOTOGRAPHS OF THE MOON'S FAR SIDE. E. A. Whitaker. May 18, 1962. 36 p. 8 refs.

N62-16649 Lamone Geological Observatory, Columbia U., Palisades, N. Y.
DESIGN AND CONSTRUCTION OF A LUNAR SEISMOGRAPH PROTOTYPE MODEL. Final Technical Report.
M. Ewing. June 27, 1962. 160 p.

(NASA Contract NASw-82; Contracts JPL-950157 and JPL-950049)
OTS: $11.50 ph, $5.00 mf.

A prototype seismograph system is described for soft-landing on the lunar surface as a part of the Surveyor payload. The system consists of a three-component long-period seismometer, a one-component short-period vertical seismometer, a course leveling device, and a servosystem for leveling to within 10 seconds. The long-period seismometer has a free resonant period of 15 seconds and transducer amplifiers to give maximum magnification of one million with a sensitivity of 250 millivolts per micron ground displacement amplitude. The vertical seismometer has a free resonant period of 1.3 seconds and a moving-coil transducer. These units are supported by feedback control circuitry for maintaining central alignment and a calibration system consisting of an accurate current source which is applied to the coil of each component on command. While this prototype instrument meets all of the operational specifications, further work is desired to improve its operation and reliability. (R.C.M.)

N62-16658 Manchester U. (Gt. Brit.)
STUDIES IN LUNAR TOPOGRAPHY.
Zdeněk Kopal et al. Bedford, Mass., Geophysics Research Directorate, Dec. 1961. 205 p. 31 refs. Work done in collaboration with Observatoire du Pic-du-Midi, France.
(Contract AF 61(052)-168)
(GRD Res. Notes-67; AFCRL-852)
CONTENTS:

1. DETERMINATION OF THE HEIGHTS OF MOUNTAINS ON THE MOON. Z. Kopal and G. Fielder. p. 4–26.
2. TECHNIQUES OF PHOTOGRAPHIC DETERMINATION OF THE HEIGHTS OF LUNAR MOUNTAINS, WITH APPLICATION TO THE REGION OF THEOPHILUS. D. Clarke. p. 27–46.
3. ERRORS INVOLVED IN THE PHOTOGRAPHIC DETERMINATION OF LUNAR HEIGHTS, AND A PRELIMINARY STUDY OF THE REGION OF PTOLEMAEUS AND ALPHONSUS. G. Turner. p. 47–71.
4. MEASURED PROFILES OF THE MOON'S SURFACE, AND THE ESTIMATES OF MAGNITUDES OF THE ERRORS IN RELATIVE ALTITUDES. G. Fielder. p. 72–107.
5. A SYSTEMATIC MICRODENSITOMETRIC TECHNIQUE AND ITS APPLICATION TO FORMATIONS IN THE MARE IMBRIUM. T. W. Rackham. p. 108–136.
6. MEASURED HEIGHTS OF LUNAR MOUNTAINS IN THE SOUTH-EASTERN PART OF MARE TRANQUILITATIS. G. Turner. p. 137–149.
7. MEASUREMENTS OF THE HEIGHTS OF THE WALLS OF THE CRATER ARCHIMEDES. G. Turner. p. 150–160.
8. A CATALOGUE OF MEASURED HEIGHTS IN THE REGIO MONTANUS AND HELL PLAIN REGIONS OF THE MOON. G. Turner. 161–186.

N62-16699 Arizona U. Lunar and Planetary Lab., Tucson.
COMMUNICATIONS OF THE LUNAR AND PLANETARY LABORATORY. VOLUME I, NUMBER II.
Gerard P. Kuiper and Barbara Middlehurst, eds., et al. 1962. 127 p. 5 refs.
(NASA Grant NsG-161-61)
CONTENTS:
No. 11. CONSOLIDATED CATALOG OF SELENOGRAPHIC POSITIONS. D. W. G. Arthur. June 19, 1962. 124 p. 5 refs.

N62-16730 Geophysics Corp. of America, Bedford, Mass.
LYMAN-ALPHA AND THE LUNAR LIMB.
Richard J. Levy. June 1962. 8 p. 5 refs.
(Contract AF 33(616)-7413)
(GCA-TR-62-13-A)

This paper deals with measurements involving the lunar limb observed in Lyman-α radiation. The main question was: Which would be brighter, the moon reflecting solar Lyman-α emission, or the diffuse background glow caused by interplanetary Lyman-α radiation? The answer to this question would determine whether the moon would appear silhouetted against a bright background or whether the moon would appear brighter than its background. From measurements made by the Naval Research Laboratory it was known that the diffuse Lyman-α glow of the night sky was $\sim 2.7 \times 10^{-5}$ erg cm^{-2} sec^{-1} ster^{-1} in the antisolar direction and slightly brighter in other directions. The reflectivity of the moon was estimated by extrapolation for the Lyman-α radiation wavelength of 1216 A because it was not known below 2200 A. Consequently, the surface brightness of the moon was found to be $\leq 4 \times 10^{-4}$ erg cm^{-2} sec^{-1} ster^{-1}. It was thus demonstrated that the background in all instances exceeds the lunar brightness by at least one order of magnitude. In Lyman-α light, the moon therefore, appears silhouetted against the background. (A.S.)

N62-16884 Aerospace Information Div., Washington, D.C.
LUNAR SURFACE FORMATIONS.
Aug. 22, 1962. 2 p. Review of: A. M. Benevolenskiy. Role of cumulative processes in the formation of lunar craters. Byull. Vsesoyuz. Astronomo-Geodezicheskogo Obshchestva (Moscow), no. 30. (37), 1962. p. 20-27.
(AID-62-122) OTS: $1.10 ph, $0.80 mf.

An hypothesis of the evolution of lunar topography is presented as follows: The lunar craters and cirques were formed in a remote selenological era when the lunar surface was still hardening. Meteorite impacts occurring at cosmic velocities on the unprotected lunar surface caused cumulative topographical phenomena on a massive scale. After the lunar surface hardened, endogenic factors such as volcanic activity became the relief-forming agents. At one critical stage in the evolution, cumulative ejection of lunar matter led to the scattering of this material into space. The crust near the central peaks of craters is the thinnest so volcanic activity is most likely to occur in these areas. This hypothesis is supported by an analogous experiment in which solid bodies were dropped onto a viscous surface (tar, cement, or gypsum) at the moment of hardening, causing a hole to form in the liquid surface. The collision of liquid particles rushing to fill the hole causes a small cumulative droplet to be ejected upward at a high kinetic energy to a considerable height. Solid models of typical lunar ring formations were obtained in this way, exhibiting surrounding walls, steep internal slopes, gentle external slopes, concave bottoms, rays, and clefts. This hypothesis reconciles the meteoritic and volcanic theories of lunar landscape formation, and may also explain the origin of tektites. (M.P.G.)

N62-16885 Aerospace Information Div., Washington, D.C.
LUNAR LIGHT POLARIZATION.
Sept. 19, 1962. 3 p. Review of: Ye. K. Kokhan. Investigations, conducted in three regions of the spectrum, of the degree of polarization and of the angle of the plane of polarization of light reflected from lunar details. Izv. Akad. Nauk SSSR. Komis. Fiz. Planet, no. 1, 1959. p. 41-53.
(AID-62-142(Supplement to AID-62-4)) OTS: $1.10 ph, $0.80 mf.

The polarization properties of lunar formations were investigated in the total luminous flux and in the blue and yellow spectral regions. The polarization of lunar light was observed from 1955 through 1958 on two electropolarimeters: the "Pulkovo", mounted on the ACN-4 mirror-lens camera (D = 1.5m, F = 325 mm) and the "Abastumani", mounted on a 16" refractor (F = 6.8m). The percent of polarization was computed from the sine curve on the continuous film recording. The conclusions made from this study are: 1) The degree of polarization of all details is greater in the blue light than in the yellow. 2) At phase angles $\pm 27.5^\circ$ the degree of polarization is equal to zero in all light. 3) Negative polarization is observed between phase angles $\pm 27.5^\circ$. 4) Maximum negative polarization

occurs at phase angles ±14°. 5) Lunar seas yield the greatest polarization. 6) The position of the plane of polarization on the moon depends upon the phase angle. 7) No difference is observed in the position of the planes of polarization in total light, in blue light, or in yellow light. 8) At the moment of full moon a very rapid rotation of the plane of polarization takes place. (R.C.M.)

N62-16888 Aerospace Information Div., Washington, D.C.
LUNAR RADIO EMISSION.
Sept. 21, 1962. 2 p. Review of: V. S. Troitskiy. Radio emission from the moon; the physical state and nature of its surface. Izv. Akad. Nauk SSSR. Komis. Fiz. Planet, no. 3, 1961. p. 16-29.
(AID-62-149 (Supplement to AID-62-4)) OTS: $1.10 ph, $0.80 mf.

Measurements of lunar radio emission on wavelengths of 0.4 to 3.2 cm conclusively show that the surface layer of the moon is approximately homogeneous, at least to a depth of about one meter. These findings invalidate the hypothesized two-layer structure. On the basis of electrical parameters, studies (of the relationship between electromagnetic wave penetration and thermal wave penetration) show that the upper lunar cover can be compared with terrestrial rocks and does not contain any significant admixtures of metal powder, such as meteoric iron. These findings support the contention of an endogenic origin of the lunar cover. Comparison of the electrical parameters of lunar and terrestrial rocks indicates a low density for the former, resulting from high porosity. The high porosity argues against a dust structure. From the ratio of the true temperature of the lunar surface and the first harmonic of its change, the true midday and midnight temperature at the surface of the moon were found to be 423° K and 133° K, respectively. (V.D.S.)

N62-16889 Aerospace Information Div., Washington, D.C.
LUNAR CRATERS.
Sept. 21, 1962. 2 p. Review of: T. A. Polozhentseva. On the state of Alphonsus crater before the onset of the eruption of 3 Nov. 1958. Izv. Akad. Nauk SSSR. Komis. Fiz. Planet, no. 3, 1961. p. 46-49; and N. P. Barabashov and V. I. Yezerskiy. Spectrophotometric observations of lunar craters. Ibid., p. 50-55.
(AID-62-150 (Supplement to AID-62-4)) OTS: $1.10 ph, $0.80 mf.

A reexamination of the spectrograms of Alphonsus crater obtained a few hours before the onset of its eruption on Nov. 3, 1958, indicates that neither a dust nor a gas cloud preceded the eruption. The spectrograms showed a noticeably attenuated central peak in the violet, which was previously attributed to the ejection of volcanic ash dust. The new interpretation attributes the energy distribution of this central peak to differences in the spectral reflecting power of individual sectors of the Alphonsus crater. (M.P.G.)

N62-17013 Aerospace Information Div., Washington, D.C.
LUNAR MICRORELIEF
Sept. 19, 1962 2 p Review of: N. N. Sytinskaya Probable dimensions of irregularities in the microrelief of the lunar surface Izv. Akad. Nauk SSSR Komis. Fiz. Planet, no. 1, 1959 p 81-84
(AID-62-141 (Supplement to AID-62-4)) OTS: $1.10 ph, $0.80 mf

The size of the irregularities in the lunar microrelief has been estimated by comparing the character of reflected radiant energy from the lunar surface in the optical and the decimeter ranges. The degree of smoothness of the surface of a celestial body is indicated by the amount of limb darkening, or, quantitatively, by the so-called smoothness factor, q. For an ideal mirror surface, q will be infinitely large; for an ideally dull (orthotropic) surface, q = 1; for a dissected surface, q < 1, and the degree of dissection is inversely proportional to the q-factor. Lunar objects were measured according to light groups (continents) and dark groups (seas), and values were arranged according to the object's distance from the center of the disk at mean libration values. Brightness factors showed no evidence of limb darkening on the moon for either continents or seas; therefore, with respect to the visual wavelength range, the lunar surface has a smoothness factor q equal to zero, attesting to a highly dissected microrelief with irregularities that are not larger than 1μ. Radar investigations (1.7-m wavelength) show that the lunar surface is very smooth; therefore, with respect to radio waves, the lunar surface approximates a mirror surface whose irregularities are smaller than 1.7 m. Consequently, the majority of the values of diameter d of lunar microrelief satisfy the inequality $1\mu \ll d \ll 1.7$ m; however, since the dark powdery matter in the optical wavelength range produces almost orthotropic scattering, the following inequality is possible: 0.1 mm < d < 0.1 m. On the basis of investigations of powders in the optical range, it is finally concluded that the dimensions of lunar microrelief irregularities are most likely 0.1 mm to 10 cm. V.D.S.

N62-17014 Aerospace Information Div., Washington, D.C.
LUNAR TEMPERATURE MEASUREMENTS
Sept. 19, 1962 3 p Review of: Yu. N. Chistyakov Attempt at determining the temperature of separate sectors of the lunar surface Izv. Akad. Nauk SSSR Komis. Fiz. Planet, no. 2, 1960 p 46-54
(AID-62-144)(Supplement to AID-62-4) OTS: $1.10 ph, $0.80 mf

The temperature of separate sectors of the lunar surface was measured with a vacuum thermoelement (sensitivity, 10 V/W) set in the Newton focus of the 13-inch reflector at Abastumani Observatory. The amount of water vapor determining the absorption of planetary heat in the atmosphere was computed with Hann's empirical formula; the formula relates the amount of water vapor in a 1-cm² column of atmosphere over the earth's surface to the absolute humidity at the surface. Computational results show that the temperature of the subsolar point for a phase angle of 17.2 degrees is 375°, which coincides with the value derived theoretically by Pettit for the full moon. The temperature of seas is about 10° higher than that of the adjacent continents. The ratio of the visual and radiometric albedos of separate points is the same as the ratio of mean albedos over the disk. V.D.S.

N62-17309 Space Technology Labs., Inc., Los Angeles, Calif.
THE LUNAR PROBLEM. VOL. I: BIBLIOGRAPHY. VOL. 2: INDEX
L. R. Magnolia and J. R. Trew Oct. 1961 Vol. 1, 272 p Vol. 2, 29 p 1030 refs Vol. 2 contains author, source and subject indices
(STL/AB-61-5110-40) Available from Space Technology Labs.

This bibliography is composed of annotated and abstracted lunar references, arranged alphabetically by corporate source or by author when no corporate source is given. The index, in the second volume, is arranged according to author, source, and fields of interest to the lunar problem. M.P.G.

N62-17341 Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
MEASURING LUNAR PROPERTIES FROM A SOFT-LANDER
Manfred Eimer July 1962 5 p Repr. from Astronautics, July 1962 p 30-33
(NASA Contract NAS7-100)
(JPL-TR-32-282) OTS: $1.10 ph, $0.80 mf

A variety of instruments will be used in an unmanned stationary lunar laboratory to observe the physical properties, texture, petrology, body structure, fields, atmosphere, and ionosphere of the moon. Lunar texture can be observed by sequentially or simultaneously viewing the surface in color or in stereo, or by viewing at various surface resolutions in a range beginning with a fraction of a millimeter. The physical properties that must be known for a comprehensive understanding and description of the lunar surface and subsurface material can be grouped as follows: density, thermal properties, acoustic properties, electromagnetic properties, and penetrability. Density can be measured by a gamma-ray backscattering method (emplacing a collimated gamma source and a collimated counter on or below the surface); temperature, by means of a total radiation pyrometer; acoustic properties, by recording arrival times, amplitudes, and wave

shapes of signals received at geophones emplaced by the spacecraft; electrical properties, by determining changes produced in inductive and capacitive devices placed near lunar material; magnetic susceptibility, by determining the mutual induction caused by the presence of lunar material; and penetrability, by means of an indentation penetrometer. Petrological analysis will involve elemental analysis (using alpha activation, neutron activation, mass spectrometery, X-ray spectrometry, etc.); mineralogical analysis (using X-ray diffractometer); visual microscopic examination (using petrographic microscope system); and determination of volatile constituents (using gas chromatograph). In order to understand the body structure of the moon, the natural modes of the moon's oscillations should be observed by means of a three-axis seismic instrument that can detect motions on the order of 10 millimicrons. A measurement of the local magnetic field can be made with a three-axis magnetometer on or near the spacecraft. A possible lunar ionosphere can be examined by observing the variations in radio signals originating in the galaxy. The pressure of a lunar atmosphere could possibly be measured by a Redhead gauge. V.D.S.

N62-17492 Colorado School of Mines Research Foundation, Inc., Golden

GEOLOGICAL AND THERMODYNAMIC ASPECTS OF LUNAR ROCKS Technical Report [Mar 1961-June 1962]

Peter C. Badgley, Felix C. Jaffe, H. Gordon Poole, and Peter L. Siems Holloman AFB, N. Mex., Directorate of Research Analyses, July 1962 95 p 68 refs

(Contract AF 29(600)-2878)

(AFOSR/DRA-62-11)

This report covers geological and thermodynamic aspects of lunar rocks. Basic problems of lunar geology are considered to establish criteria for statistical methods so as to establish whether these features originated by a volcanism or impact. The thermal stability of typical oxides is considered and it is found to be thermodynamically feasible to obtain oxygen from silica or certain other oxides that will probably be found on the moon. Author

N62-17662

100 INCH REPRODUCTION OF 300 INCH MAP OF THE MOON—SECTIONS I-XXV

Hugh Percy Wilkins 1937-1951 Third edition 25 sheets, 21 1/8" x 21 5/8" Maps only; no text Printed by W. F. Stanley & Co., Ltd., 13, Railway Approach, London Bridge, S. E. I.

N62-17663 Instituto Brasileiro de Astronáutica e Ciências Espaciais, São Paulo

A LUA—CARTA SELENOGRAFICA [THE MOON—SELENOGRAPHIC CHART]

Dulcidio Dibo 1962 2 maps with tables and projections on single sheet 37½" x 29½"

(Astronomy Series No. 1)

This selenographic chart is for both sides of the moon. The data for the back side was taken from Russian photographs. R.C.M.

N62-17750 Joint Publications Research Service, Washington, D.C.

NEW SOVIET STUDY OF THE LIMB ZONE OF THE MOON

Anton Ageyevich Gorynya and Vasiliy Kirillovich Drofa Sept. 18, 1962 16 p Transl. of the preface of the book "Rel'yef Krayevoy Zony Luny" (Relief of the Limb Zone of the Moon) Kiev, Publishing House of the Acad. of Sci. Ukrain. SSR, 1962 164 p

(JPRS-15324) OTS: $1.60

Lunar limb studies have been made to determine the relation between optical librations and the radius of the visible lunar disc. The photographs used in this study were taken between 1950 and 1955 on the Kiev State University astrograph (D = 200 mm, F = 4.3 m). The processing of these photographs included the determination of the scale, correction for refraction, and calculation of radii of the most probable circles from several points on the lunar profile. These data are used to determine the inclination of the real limb of the moon. After correcting the optical libration for the dependence on the optical density of the negative, it is shown that the radius depends on the optical libration in latitude as well as in longitude. R.C.M.

N62-17762 Joint Publications Research Service, Washington, D.C.

SOVIET-BLOC RESEARCH IN GEOPHYSICS, ASTRONOMY, AND SPACE, NO. 36, 1962

A. V. Markov et al May 31, 1962 36 p 46 refs Contains abstracts, summaries, and translations of articles from recent publications of the Sino-Soviet Bloc countries

(JPRS-13931) OTS: Annual subscription, $16.00

This report contains information on the following: astronomy, meteorology, oceanography, terrestrial geophysics, and upper atmosphere and space research. J.R.C.

N62-17884 Joint Publications Research Service, Washington, D.C.

SOVIET-BLOC RESEARCH IN GEOPHYSICS, ASTRONOMY, AND SPACE, NO. 46, 1962

G. Arakelyan et al Oct. 31, 1962 27 p 45 refs Contains abstracts, summaries, and translations of articles from recent publications of the Sino-Soviet Bloc countries

(JPRS-15976) OTS: Annual subscription, $16.00

Material gathered from recent publications of the Sino-Soviet Bloc countries is presented in the form of abstracts, summaries, and occasional full translations of articles on subjects of astronomy, meteorology, oceanography, geophysics, and atmosphere and space research. Complete bibliographic information accompanies each article. V.D.S.

N62-17940 General Electric Co. Electronics Lab., Syracuse, N.Y.

STUDY OF THE STATISTICAL PROPERTIES OF MICROWAVE FIELDS NEAR AN IRREGULAR REFLECTING SURFACE WITH APPLICATION TO SOFT LUNAR LANDING Final Report, Period July 1, 1961 thru Apr. 15, 1962

F. R. Dickey, Jr. May 15, 1962 114 p refs

(NASA Contract NAS5-1188)

(R62ELS-42) OTS: $9.60 ph, $3.62 mf

A preliminary study, including experimental simulation, has been made of the statistical properties of microwave fields in the vicinity of a large irregular surface illuminated from a distance, as measured by moving probes. The application is to soft lunar landing, the primary object being to determine the feasibility of sensing the velocity vector, including spacecraft attitude relative to direction of motion, by means of cross-correlation between spaced microwave receivers. The results indicate that a sensor equivalent to a self-contained Doppler radar, but lighter in weight and capable of working at much higher altitudes than a Doppler radar, may be feasible. However, much further study and experimentation is indicated. Author

N62-17976 Jet Propulsion Lab., Calif., Inst. of Tech., Pasadena

SCIENTIFIC EXPERIMENTS FOR RANGER 3, 4, AND 5

Oct. 1, 1962 29 p 10 refs

(NASA Contract NAS7-100)

(JPL-TR-32-199 (Rev.)) OTS: $2.60 ph, $1.07 mf

This report presents descriptions of the scientific experiments to be carried on *Ranger 3, 4,* and *5* spacecraft—the first spacecraft designed to land operating instrument packages on the Moon's surface. The experiments include a vidicon camera to obtain close-up pictures of the Moon's surface and show small-scale geological land forms and features. A gamma-ray experiment will determine the approximate concentration of the different radioactive materials present in the surface of the Moon. An altimeter will obtain radar reflectivity data. These data should be valuable in the determination

of the lunar surface structure. A seismometer will be landed to obtain data regarding the inner structure of the Moon and the magnitude and depth of any seismic activity. Author

1963

N63-10225 Lowell Observatory, Flagstaff, Ariz.
PHYSICS OF THE PLANETS
William M. Sinton *In* Virginia Polytechnic Inst., Blacksburg. Physics of the Solar System, Part I. Proc. of the Conf. on Physics of the Solar System and Reentry Dynamics, July 31 to Aug. 11, 1961 p 126-165 (See N63-10220 01-05) VPI: $1.50
Portions of this paper appear in The Moon—Its Astronomy and Physics. N. Y., Academic Press., 1961

Planetary physics is discussed in terms of observations made from the earth. The methods of observing the planets are reviewed. The data obtained are related to planetary surfaces and atmospheres. R.C.M.

N63-10227 Lincoln Lab., Mass. Inst. of Tech., Lexington
RADAR STUDIES OF PLANETARY SURFACES
G. H. Pettengill *In* Virginia Polytechnic Inst., Blacksburg. Physics of the Solar System, Part I. Proc. of the Conf. on Physics of the Solar System and Reentry Dynamics, July 31 to Aug. 11, 1961 p 210-236 33 refs (See N63-10220 01-05) VPI: $1.50

Radar studies of the planetary and lunar surfaces are reviewed to point out the principal contributions they have made to knowledge of these bodies. The data obtained from these studies include the path loss, echo delay, Doppler shift, and surface effects. These data have provided knowledge of the moon and planets in three major areas: (1) the dynamics of the orbits, (2) the composition of the materials of the surface, and (3) the geography of surface features visible at radio-wavelengths. R.C.M.

N63-10228 Lincoln Lab., Mass. Inst. of Tech., Lexington
RADAR METHODS OF STUDYING DISTANT PLANETARY SURFACES
John V. Evans *In* Virginia Polytechnic Inst., Blacksburg. Physics of the Solar System, Part I. Proc. of the Conf. on Physics of the Solar System and Reentry Dynamics, July 31 to Aug. 11, 1962 p 237-259 23 refs (See N63-10220 01-05) VPI: $1.50

The techniques available to radar astronomy are reviewed to determine their usefulness in studying the roughness characteristics of lunar and planetary surfaces. It is shown that radar measurements yield information only about the presence of irregularities on the surface that have sizes ranging from less than one to tens of wavelengths. Structures which are considerably smaller than the wavelength may never be detected and large structures may be examined only if they are not covered by smaller irregularities. It is concluded that the present techniques can only provide a measure of the fractional amount of surface which has a roughness of the same size as the wavelength and the average gradient of the remainder. R.C.M.

N63-10334 Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena.
SPACE PROGRAMS SUMMARY NO. 37-17, VOLUME VI FOR THE PERIOD JULY 1, 1962 TO OCTOBER 1, 1962. SPACE EXPLORATION PROGRAMS AND SPACE SCIENCES
Oct. 31, 1962 67 p 5 refs
(NASA Contract NAS7-100)
(JPL Space Programs Summary 37-17, Vol. VI) OTS: $6.60 ph, $2.21 mf

This report covers the space exploration programs and space sciences as follows: the Ranger, Surveyor, Mariner, and Voyager Projects; the DSIF tracking of Mariner 2; geophysical instruments for lunar exploration; television subsystems for planetary studies; and a study of the Odessa iron meteorite. R.C.M.

N63-10371 Northrop Space Labs., Hawthorne, Calif.
PRELIMINARY LOCOMOTION ANALYSIS OF LUNAR SURFACE VEHICLES
W. B. Sponsler *In* Air Force Systems Command. Office of the Deputy Commander for Aerospace Systems, Los Angeles, Calif. Transactions of the 7th Symp. on Ballistic Missile and Space Technol., U. S. Air Force Academy, Colo., Aug. 13–16, 1962 Vol. I p 23–52 14 refs (See N63-10370 01-01)

This paper summarizes a preliminary study of vehicular mobility on the lunar surface. Basic modes of controlled locomotion are discussed, and the most promising (rigid and flexible wheels and tracks) are analyzed. The effects of surface characteristics, vehicle weight and tread configuration are related to traction, rolling resistance, range, obstacle capability and acceleration. Typical examples are compared, varying the lunar surface parameters to develop a relative evaluation and to present a method for further analysis. The necessity for slow speeds and the effects of lunar environment upon traction, ride, stability, braking and other factors are also discussed. Author

N63-10372 Armour Research Foundation, Chicago, Ill.
PENETRATION STUDIES OF SIMULATED LUNAR DUST
R. D. Towe and E. T. Selig *In* Air Force Systems Command. Office of the Deputy Commander for Aerospace Systems, Los Angeles, Calif. Transactions of the 7th Symp. on Ballistic Missile and Space Technol., U.S. Air Force Academy, Colo., Aug. 13-16, 1962 Vol. I p 53-72 3 refs (See N63-10370 01-01)

Results are presented for the static and dynamic penetration resistance of a simulated lunar dust in a hard vacuum environment. Specimens of finely ground silica, covering a range of densities, were tested at a number of absolute pressures from one atmosphere down to 5×10^{-6} torr. While the nature of their behavior was somewhat different, both static and dynamic penetration resistance were found to depend significantly on initial specimen density and on vacuum levels, increasing with an increase in density or a decrease in pressure. Author

N63-10526 Joint Publications Research Service, Washington, D. C.
SOVIET-BLOC RESEARCH IN GEOPHYSICS. ASTRONOMY AND SPACE, NO. 48, 1962
Gennadiy Vorob'yev Nov. 30, 1962 31 p 46 refs Contains abstracts, summaries, and translations of articles from recent publications of the Sino-Soviet Bloc countries
(JPRS-16455) OTS: Annual subscription, $16.00

This semimonthly serial publication consists of materials gathered from recent publications of the Sino-Soviet Bloc Countries, presented in the form of abstracts. Author

N63-10702 California U., Berkeley. Space Sciences Lab.
POSSIBLE ELEMENTAL ABUNDANCES OF THE LUNAR CRUST
Ann Palm and Robert G. Strom Repr. from Publ. Astron. Soc. Pacific, v. 74, no. 439, Aug. 1962 p 316-322 10 refs
(NASA Grant NsG-145-61)

Possible rock types consonant with some of the recent hypotheses concerned with the origin of the moon's surface structures have been derived. These materials were compared with common terrestrial rocks, meteorites, and tektites of known chemical compositions, and a most probable set of elemental abundances of the lunar crust was deduced for each hypothesis. Oxygen, Si, Al, Fe, Mg, Ca, Na, K, and Ni are the principal elements that distinguish the rock types. Therefore, the abundance ratios of these elements constitute one of the important criteria for deciding whether volcanic or impact mechanisms predominated in the shaping of the surface features. J.R.C.

N63-10997 California U., Berkeley. Space Sciences Lab.

A POSSIBLE ORIGIN OF THE LUNAR WALLED PLAIN, PTOLEMAEUS

Robert G. Strom and A. Palm Oct. 15, 1962 15 p 18 refs
(NASA Grant NsG-145-61)
(*Its* Ser. 3, Issue 24) OTS: $1.60 ph, $0.80 mf

The tectonic associations between the diverse features in Ptolemaeus and the regional radial and parallel grid systems have been investigated. On the basis of this analysis, it has been concluded that Ptolemaeus represents a collapse feature and that it underwent a protracted development. Author

N63-11013 Joint Publications Research Service, Washington, D.C.

SOVIET-BLOC RESEARCH IN GEOPHYSICS, ASTRONOMY, AND SPACE, NO. 29, 1962

K. V. Kuvshinova et al Feb. 15, 1962 42 p 65 refs Contains abstracts, summaries, and translations of articles from recent publications of the Sino-Soviet Bloc countries
(JPRS-12445) OTS: Annual subscription, $16.00

This report, containing abstracts, summaries, and translations, covers the following: astronomy, meteorology, oceanography, terrestrial geophysics, and upper atmosphere and space research. J.R.C.

N63-11017 Manchester Coll. of Science and Tech. (Gt. Brit.)

LABORATORY SIMULATION OF LUNAR LUMINESCENCE Annual Summary Report No. 2

J. E. Geake, M. D. Lumb, and J. Derham Mar. 1962 7 p
(Grant AF-EOAR 61(052)-379)
(AFCRL-62-1099)

Instrumentation for laboratory simulation of lunar luminescence is practically completed, and the luminescence of some tektite and meteoric samples has been investigated. The grating monochromator has been completed and calibrated, and the equipment for ultraviolet and proton excitation has been designed so that the luminescence excited by UV and protons can be investigated one after the other with the sample in the same place. A few tektite and meteoric samples have been scanned with this equipment; also, arrangements have been made to use the large collection of meteoric material in the British Museum. M.P.G.

N63-11018 Manchester U. (Gt. Brit.)

RESEARCH STUDY AND DEVELOPMENT OF 1 METRE-MIRROR FOR MOON TRACKING AND PHOTOGRAPHY Annual Summary Report No. 2

Zdeněk Kopal Mar. 1962 11 p
(Contract AF 61(052)-400)
(AFCRL-62-1100)

The optics for the 43-inch telescope, ordered the previous year, was delivered up to specifications and installed at the Observatoire du Pic-du-Midi in preliminary mounting in November 1961. Extensive optical tests of the 43-inch mirror in the factory at Newcastle and in its cell on Pic-du-Midi—both visual and photographic—have revealed the optical surface to be correct within $\pm \lambda/20$ over 90% of its effective arc; slightly larger deviations have been encountered only within the last 7-cms. of its free aperture. The first photographs of the Moon, secured with the aid of this mirror in a f/15 Cassegrain combination immediately after the end of the period covered by this report, are of excellent quality and augur well for the future. Author

N63-11019 Manchester U. (Gt. Brit.)

SPECTROPHOTOMETRIC STUDY OF THE LUNAR SURFACE Annual Summary Report No. 2

Zdeněk Kopal Mar. 1962 12 p 2 refs
(Contract AF 61(052)-378)
(AFCRL-62-1096)

The instruments designed for the study of lunar luminescence as well as for the measurement of the polarization of moonlight during the period covered by the last year's Annual Summary Report have been built in our laboratories at the University of Manchester, and their field use commenced both at the 50-inch reflector of Asiago Observatory of the University of Padua and the 15-inch refractor of the Wilfred Hall Observatory at Preston, Lancashire.

Preliminary results of the reduction of observations do disclose the presence of an appreciable luminescent component in moonlight, amounting to a few percent of the total. There is, moreover, evidence on hand (though not yet definitive) that the amount of luminescence fluctuates both with the time and in frequency; but it will be the task of further observations planned for the period immediately following that covered by this report, to establish this with final validity. Author

N63-11273 Martin Co., Baltimore, Md.

THERMAL ASPECTS OF LONG-TERM STORAGE OF PROPELLANTS ON THE LUNAR SURFACE

Tibor Buna N.Y., Am. Rocket Soc. [1962] 37 p 15 refs Presented at the ARS 17th Annual Meeting and Space Flight Exposition, Los Angeles, Nov. 13-18, 1962
(ARS Paper-2690-62) ARS: $0.50 members, $1.00 nonmembers

The passive thermal control aspects of above-surface storage of propellants on a lunar equatorial site are examined. A method is developed for predicting vaporization rates, mean temperatures and temperature amplitudes of insulated propellants exposed to stabilized-periodic heating in the lunar environment. It is shown that, with modest investment in required insulation weights, propellant temperature levels comparable to earth-ambient temperatures may be maintained indefinitely on the lunar surface, and boil-off rates of cryogenic propellants may be kept within acceptable limits for storage times up to several lunar cycles. The feasibility of artificially modifying the effective reflectivity of the lunar surface is established, and the effect of such modification on performance is evaluated. The relative effects of surface optical properties, insulation heat transfer mechanism (conduction versus radiation) and the spatial and temporal distribution of the environmental radiation intercepted by the container are discussed in the light of three insulation concepts. Author

N63-11407 RAND Corp., Santa Monica, Calif.

STUDIES OF THE PHYSICAL PROPERTIES OF THE MOON AND PLANETS Quarterly Technical Progress Report (8) [April 1, 1962 to June 30, 1962]

July 1962 12 p 4 refs
(NASA Contract NAS7-100; Contract JPL N-33561)
(AR-26-JPL) OTS: $1.60 ph, $0.80 mf

Studies of the physical properties of the moon and planets are reported. These include the following: planetary atmospheres, radiative transfer, atmospheric scattering, an isostatic model of the moon, cosmogonic studies, optical tracking of deep-space probes, and planetary orbiters. R.C.M.

N63-12032 Boston U., Mass.

THE TRANSFORMATION BETWEEN CARTESIAN AND CONIC COORDINATES Research Report No. 1

L. Belsky Aug. 1962 40 p 1 ref
(NASA Grant NsG-246-62)
(*Its* Astronom. Contrib., Ser. II, No. 21) OTS: $3.60 ph, $1.40 mf

A solution for the transformation constants between two 2-dimensional systems of coordinates with noncoincident centers of coordinates is obtained. Cartesian and conical coordinate systems were used. Since the coordinates are subject to error, measured coordinates of more than the six required points were necessary. The root mean-square values of the transformation constants were obtained by requiring the difference between the measured and the calculated values of the coordinates to be a minimum. Equations used to prepare the IBM reduction program are given, as well as copies of the program in FORTRAN language as it was fed to the IBM 1620. A short program appears in the FORTRAN statement for processing and printing the data on craters when this procedure is applied to the study of lunar photography. I.v.L.

N63-12041 Boston U., Mass.

THE PLATE CONSTANTS OF MOON PHOTOGRAPHS Research Report No. 2

Badri Aghassi Sept. 1962 12 p 3 refs

(NASA Grant NsG 246-62)

(*Its* Astronomical Contributions, Ser. II, No. 18) OTS: $1.60 ph, $0.80 mf

A computational method for obtaining the selenographic coordinates of points on a fragment of a photograph of the moon, without translating and rotating the systems of axes to fit Saunder's concentric solution, is presented. In this method, the loci of constant ξ, η, and ξ are considered as three families of parallel coaxial circles. Since in an orthographic projection these circles project as three families of elipses of the same ellipticity, an equation of conics can be written which fits ξ and η as polynomial functions of the vectors x and y. A correction for the deformation caused by the conic projection is given, although this is considered to be negligible. Results were computed for the coordinates of the center of the disc and for the scale and inclination of the photograph. M.P.G.

N63-12043 New Mexico U. Engineering Experiment Station, Albuquerque

LUNAR SURFACE CHARACTERISTICS BASED ON RADAR AND PHOTOGRAPHIC DATA Semi-Annual Progress Report

Donald H. Lenhert, W. W. Koepsel, Richard Bechtel, Nasir Ahmed, and Frank Janza Oct. 1962 38 p refs

(NASA Grant NsG-129-61)

(PR-39) OTS: $3.60 ph, $1.34 mf

Lunar surface characteristics based on radar and photographic data include the following investigations: (1) correlation of radar and photographic data with major emphasis upon the use of the reflected radar pulse envelope and a photograph of the area of return to determine possible correlation between radar scattering and light scattering from a given terrain; and (2) variations and effect of R^{-n} Fresnel zone transitions in the estimation of lunar surface roughness. To avoid the problems occurring at microwave frequencies, data were taken using an acoustic radar simulator. Results indicate that the power return varies as R^{-4} when the excitation phase is less than $\lambda/4$ across the reflector. An R^{-3} power return occurs when the phase difference is between $\lambda/2$ and $\lambda/4$ and finally an R^{-2} power return occurs for phase difference greater than $\lambda/4$ across the plate. I.v.L.

N63-12071 Boston U., Mass.

IMPACTS ON THE EARTH AND MOON Research Report No. 3

Gerald S. Hawkins Nov. 1962 7 p

(NASA Grant NsG-3246-62)

(*Its* Astronomical Contributions, Ser. II, No. 20) OTS: $1.10 ph, $0.80 mf

A study has been made of statistics of the number and size of meteoritic impacts on the surface of the earth. The statistics studied also indicated whether the meteorite was stone or iron. From these statistics, equations were derived by assuming that 1/10 of a stone and 1/5 of an iron is recovered. It may be assumed from this study that the impact rates for the surface of the moon are one-half the impact rates for the earth when allowance is made for the effect of concentration caused by the earth's gravitational field. Tables are appended which show the cumulative number of impacts on the moon during 3×10^9 years. The tables are arranged to show the mass, stone meteorites, iron meteorites, asteroids, comets, and combined stones and irons in impacts. A.S.

N63-12149 General Electric Co. Defense Systems Dept., Santa Barbara, Calif.

COMPENDIUM OF STUDIES AND REPORTS RELATING TO: LUNAR INVESTIGATIONS—ASTRODYNAMICS—SPACE VEHICLE RECOVERY

May 1962 14 p 23 refs

Available information on lunar investigation, astrodynamics, and space vehicle recovery is summarized. Reports on manned and unmanned lunar exploration include analyses of environment, systems, vehicles, communications, power supplies, survey and navigation, and earth-based equipment. Astrodynamic reports include the derivation of expressions for the effect of terrestrial harmonics on satellite orbits, and orbit prediction theory. Space vehicle recovery studies include evaluation of criteria for site selection and establishment of an order of site preference based on security, safety, terrain, climate, facilities, equipment, search problems and aids, and control center availability. M.P.G.

N63-12201 Joint Publications Research Service, Washington, D.C.

SOVIET ASTRONOMICAL REPORTS

Jan. 29, 1963 93 p 56 refs Transl. of 3 articles from Izv. Glavnoi Astron. Observ. (Kiev), v. 3, no. 2, 1961 p 27-67, 68-76, and 138-150

(JPRS-17363) OTS: $2.25

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3. THE SOLAR DIFFRACTION SPECTROGRAPH OF THE MAIN ASTRONOMICAL OBSERVATORY OF THE ACADEMY OF SCIENCES, UKRAINIAN SSR E. A. Gurtovenko and Ye. I. Didychenko p 65-90 4 refs (See N63-12204 05-05)

N63-12203 Joint Publications Research Service, Washington, D.C.

BARYCENTRIC HIGH RELIEF OF THE LIMB ZONE OF THE MOON

I. V. Gavrilov *In its* Soviet Astronomical Reports Jan. 29, 1963 p 53-64 11 refs (See N63-12201 05-05) OTS: $2.25

Barycentric high relief of the limb zone of the moon was investigated, using data on the lunar shape. I.v.L.

N63-12353 Boston U., Mass.

CATALOG OF LUNAR CRATERS I Research Report No. 4

Gerald S. Hawkins and Peter W. Mitchell Nov. 1962 24 p 3 refs

(NASA Grant NsG-246-62)

(*Its* Astronomical Contributions, Ser. II, No. 22) OTS: $2.60 ph, $0.92 mf

Selenographic coordinates of all craters observable on a selected portion of the moon's surface are given, along with the diameter of the crater and comments on its shape. Plate constants are calculated by the method described by Belsky (1962). A.R.B.

N63-12362 Texas Instruments, Inc., Dallas

RADAR ANALYSIS OF THE MOON. PHASE I: FEASIBILITY OF LABORATORY SIMULATION Final Report

Frank E. Kinsman and Jack R. Van Lopik Nov. 30, 1962 138 p 112 refs

(Contract AF 19(628)-480)

(AFCRL-62-1120)

The future use of radar in making specific-property determinations of the lunar surface is dependent upon knowledge of (a) the effects of lunar atmospheric conditions on radar propagation/operation and (b) radar reradiation signatures of possible lunar surface materials. If assessment of radar potentialities for exploration of the moon is to be made, theoretical analyses must be performed to determine possible effects that might be produced on radar propagation/operation if extreme-value estimates for lunar environmental factors are assumed to be correct. Based on currently available data and methods of analysis, such effects are shown to be relatively minor. In view of this determination and the embryonic status of radar

terrain analysis (which does not permit reliable interpretation of detailed measurements), fairly gross radar reradiation measurements of postulated lunar materials can be of great value. Radar frequencies at or near X-band (3 cm) and far-field operation are best suited for obtaining these data. Relatively simple facilities appear adequate, but radar reradiation measurements and theoretical determinations might require verification in a facility capable of simulating selected lunar atmospheric and surface conditions. In either case, it appears desirable and feasible to simulate radar analysis of the moon using state-of-the-art radar facilities and postulated lunar surface materials. Author

N63-12728 Douglas Aircraft Co., Inc., Santa Monica, Calif.
THE GEOLOGY OF THE MOON. A PARTIAL BIBLIOGRAPHY OF MEASUREMENTS AND OBSERVATIONS
D. L. Weide Dec. 1962 99 p 574 refs
(SM-42582)

N63-12785 Geological Survey, Washington, D.C.
ENGINEER SPECIAL STUDY OF THE SURFACE OF THE MOON
Robert J. Hackman and Arnold C. Mason 1961 4 p
(Its Miscellaneous Geological Investigations Map I-351)

Charts are given representing a photogeologic analysis of lunar photographs. The approximate scale of 1:3,800,000 was used to show the principal physiographic divisions, the geologic features, and the lunar rays. A table of miscellaneous geologic investigations is included. R.C.M.

N63-12894 National Aeronautics and Space Administration. Langley Research Center, Langley Station, Va.
THE ACTION OF A HYPERSONIC JET ON A DUST LAYER
Leonard Roberts N.Y., Inst. of the Aerospace Sciences, [1963] 28 p 11 refs Presented at the IAS 31st Annual Meeting, N. Y., Jan. 21-23, 1963
(IAS PAPER-63-50) IAS: $0.50 members, $1.00 nonmembers

The paper defines a theoretical model to describe the erosion and subsequent transport of dust in the vicinity of a spacecraft landing on the moon. Available experimental information is examined and a more complete description of the exhaust-jet—dust-layer interaction is established. Particular attention is paid to three important phases of the problem: (1) the gas dynamics of the exhaust, (2) the mechanics of the surface erosion, and (3) visibility through the dust cloud. It is shown that the Mach number and Reynolds number of the exhaust flow, together with certain dust parameters, determine the character of the erosion. The shape of the crater caused by this erosion is calculated and shown to be in qualitative agreement with the experimental results. The extent of the dust cloud and visibility through the cloud are shown to depend on the size of the particles and the location of the vehicle above the surface. Author

N63-12922 Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
REVIEW OF TECHNIQUES FOR MEASURING ROCK AND SOIL STRENGTH PROPERTIES AT THE SURFACE OF THE MOON
H. Carl Thorman N. Y., Soc. of Automotive Engineers [1963] 8 p 11 refs Repr. from Automotive Eng. Cong., Soc. of Automotive Engineers, Inc., Jan. 1963 Presented at the Automotive Engineering Congress, Detroit, Jan. 14-18, 1963
(NASA Contract NAS7-100)
(JPL-TR-32-374; SAE Paper-632C)

Among the various instruments which have been developed for performing post-landing experiments on the lunar surface from an unmanned spacecraft are several that provide means for observing how the lunar material responds to applied stresses. These include: penetration-hardness gages, soil-mechanics test apparatus, a subsurface-sampling rock drill, and a surface-sample collector. The design and operating features and the range of application of each of these four devices are reviewed in this paper. Author

N63-13418 Office of Research Analyses, Holloman AFB, N. Mex.
A STUDY OF RADIANT HEAT TRANSFER IN A LUNAR SIMULATION CHAMBER
Maurice W. Wilden (New Mexico U.) Jan. 1963 87 p 11 refs
(ORA-63-2)

The thermal behavior of a vertical cylinder, representing a space capsule resting on the surface of the moon, was investigated in the environment of a lunar simulation chamber by use of an analytical network method. The parameters affecting radiative heat exchange between the ceiling of the chamber, the floor of the simulator, and the cylinder were varied in the wide range of temperatures encountered during lunar day and night. The mathematical foundations of the analytical network method are explained, and the results displayed in diagrams. Author

N63-13449 Jet Propulsion Lab. Calif. Inst. of Tech., Pasadena
RANGER PREFLIGHT SCIENCE ANALYSIS AND THE LUNAR PHOTOMETRIC MODEL
A. G. Herriman, H. W. Washburn, and D. E. Willingham Jan. 7, 1963 44 p 11 refs
(NASA Contract NAS7-100)
(JPL-TR-32-384) OTS: $4.60 ph, $1.52 mf

A photometric model of the lunar mare surface is presented. The lighting parameters for the Ranger 3, 4, and 5 TV system are developed using the photometric model, and related to the system parameters. The interactions of the TV constraints with those imposed by the other experiments and by trajectory characteristics are discussed in detail, and the use of plastic spheres to show graphically the interrelationships among the parameters is described. Author

N63-13515 National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, Ala.
A CONSIDERATION OF LUNAR SURFACE BALLISTICS AND THE HAZARDS ASSOCIATED WITH SPACECRAFT LANDING OR LAUNCH OPERATIONS
D. C. Cramblit Washington, NASA, Mar. 1963 33 p 14 refs
(NASA TN D-1526) OTS: $1.00

This preliminary study was directed specifically toward determination of the trajectories or flight paths of lunar-surface particles accelerated by the jet blast from a lunar-landing or return vehicle. A range of particle velocities was assumed based on an anticipated effective exhaust gas velocity of 13,250 ft/sec for a LOX-LH_2 engine. Thus, velocities both above and below those required for escape or orbit from the lunar surface were considered. Data are presented in graph and chart form, along with a brief discussion. Sample calculations and basic data for the ballistics study are presented. Author

N63-13767 Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
THERMAL PROPERTIES OF A SIMULATED LUNAR MATERIAL IN AIR AND IN VACUUM
E. C. Bernett, H. L. Wood, L. D. Jaffe, and H. E. Martens Nov. 25, 1962 23 p 11 refs
(NASA Contract NAS7-100)
(JPL-TR-32-369) OTS: $2.60 ph, $0.89 mf

The thermal diffusivity and thermal conductivity for a crushed olivine basalt were determined from transient state data. Values were obtained over a temperature range of -100° to 200° C in vacuums of 5×10^{-3} and 5×10^{-6} mm Hg as well as at atmospheric pressure. A -150 mesh material at a density of 1.14 g/cm^3 had a thermal conductivity of 3.9×10^{-6} cal/cm sec °C at 100° C when measured in a vacuum of 5×10^{-6} mm Hg. This was approximately one hundred times lower than the values obtained for the same material measured at atmospheric pressure. Increasing the density to 1.57 g/cm^3 increased the thermal conductivity by approximately 60% in both air and vacuum. Over the range studied, the test temperature had very little effect on thermal conductivity in air but showed more of an effect when the material was placed in a vacuum. Author

N63-14087 Cornell U. Center for Radiophysics and Space Research, Ithaca, N.Y.

PHOTOMETRIC STUDIES OF COMPLEX SURFACES, WITH APPLICATIONS TO THE MOON

Bruce Hapke and Hugh Van Horn Feb. 1963 55 p 24 refs Submitted for Publication

(NASA Grant NsG-119-61)

(CRSR 139) OTS: $5.60 ph, $1.85 mf

The reflection laws of a wide variety of surfaces have been measured. The factors which govern the optical scattering characteristics of complex surfaces are discussed, and the properties of surfaces which scatter light in the same manner as the moon are specified. Surfaces of solid rocks, volcanic slags, or coarsely-ground rock powders do not possess the intricate structure necessary for backscattering light strongly. However, finely pulverized dielectric particles are able to build extremely complex surfaces which can reproduce the lunar scattering law. It is concluded that the surface of the moon is covered with a layer of fine rock dust composed of particles of the order of 10μ average diameter, and that 90% of the volume of the surface layer is voids. Author

N63-14406 National Aeronautics and Space Administration, Washington, D.C.

EVALUATION OF INFRARED SPECTROPHOTOMETRY FOR COMPOSITIONAL ANALYSIS OF LUNAR AND PLANETARY SOILS

R. J. P. Lyon (Stanford Res. Inst.) Apr. 1963 136 p 43 refs

(NASA Contract NASr-49(04))

(NASA TN D-1871) OTS: $2.75

A preliminary feasibility study of infrared analytical techniques for the study of the lunar surface has been made, including absorption studies of 370 rock and mineral samples, and reflection studies of 80 rocks. Spectral information was collected in the wavelength range 2.5 to 25 microns (4000 to 400 cm^{-1}). Emittance spectra have been calculated from the reflectance data for several of the most important rock types. Author

N63-14491 Stanford Research Inst., Menlo Park, Calif.

ERRORS IN THE MEASUREMENT OF THE TEMPERATURE OF THE MOON

Eugene A. Burns and R. J. P. Lyon 5 p 9 refs Repr. from Nature (London), v. 196, no. 4853, Nov. 3, 1962 p 463-464

(NASA Contract NASr-49(04))

Observations of the temperature and composition of the lunar crust made by instruments above the earth's atmosphere will require different interpretation techniques than data obtained through the atmosphere. Therefore, the effect of composition on the emissivity of several smooth surfaces was investigated as a function of wavelength, and the surface emittance was calculated at several temperatures. Comparisons of the emittance curves of quartz at six temperatures demonstrate that (1) the wavelength of maximum energy cannot be used to evaluate the temperature from the Wien law, and (2) the dependence of average emissivity on temperature is a second-order effect, so that measuring temperature changes of the same material by radiometric methods is valid. However, absolute values of the temperature obtained may be significantly in error. Because of the predominance of the strong Si-O vibrational bands near 9-10μ for most minerals, a situation similar to that for quartz is assumed to exist for lunar surfaces, although the porosity of the lunar surface may make the deviation from the ideal emissivity curve less obvious. M.P.G.

N63-14587 National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.

SPRAY EJECTED FROM THE LUNAR SURFACE BY METEOROID IMPACT

Eugene M. Shoemaker, Henry J. Moore (Geol. Survey), and Donald E. Gault

(NASA TN D-1767) OTS: $1.00

Experimentally determined mass-size distributions of fragments ejected from craters formed in rock by hypervelocity impact have been combined with estimates of the rate of impact and mass distribution of interplanetary debris which strikes the lunar surface to find the rate and mass of fragments sprayed up from the lunar surface. It is shown that the flux of particles of a given mass ejected from the lunar surface will be at least three and probably four orders of magnitude greater than the flux of the impacting interplanetary debris of the same mass. Experimentally determined distributions of mass with velocity indicate that almost all of the debris is ejected at less than lunar escape velocity (2.4 km/sec) and contributes to secondary impact events. A small fraction of the ejecta, however, will leave the lunar surface at velocities greater than the escape speed. These results imply the presence of a lunar dust cloud of flying particles. The major fraction of the cloud is estimated to be a few kilometers deep with a spatial density at the lunar surface of the order of 10^5 to 10^7 times the spatial density of the interplanetary debris. These particles, together with the interplanetary debris, provide a powerful eroding agent that will continually abrade the lunar surface and reduce rubble to finer sizes. The inference to be drawn is that there must be at least a thin layer of dust-sized particles on the lunar surface—a layer which is being constantly agitated and stirred by the impacts to form a heterogeneous mixture of material from the entire surface of the moon. It is to be expected that lunar probes and vehicles will be subjected to higher rates of impact when immersed in the dust cloud than during the earth-moon voyage. Author

N63-14668 Stanford Research Inst., Menlo Park, Calif.

INFRARED SPECTRAL ANALYSIS OF THE LUNAR SURFACE FROM AN ORBITING SPACECRAFT

R. J. P. Lyon and Eugene A. Burns Oct. 16, 1962 Repr. from Proc. of 2nd Symp. Remote Sensing Environment, Mich. U., Oct. 16, 1962 p 309-327 21 refs

(NASA Contract NASr-49(04))

Absorption and specular reflection analyses have been used to test the feasibility of infrared compositional analysis of lunar materials in the wavelength range 2 to 25 microns. In a NASA-sponsored study, over 300 minerals and rocks have been examined and the applicability of the techniques clearly established. By applying Kirchhoff's law to the spectral reflectance data, under thermal equilibrium conditions one can obtain the spectral-emittance curves at any given temperature. Major rock types may be readily differentiated from one another at lunar ambient temperatures. Author

N63-14677 Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena

PHOTOGRAPHY OF THE MOON FROM SPACE PROBES

Manfred Eimer Jan. 15, 1963 26 p 17 refs

(NASA Contract NAS7-100)

(JPL-TR-32-347) OTS: $2.60 ph, $0.98 mf

Photography of the moon from space probes is an essential early step in lunar exploration. From the vicinity of the earth, even diffraction-limited systems cannot conceivably be capable of providing sufficient optical resolution within the next few decades. Aspects of the photometric properties of the moon that are important to an understanding of photographic problems are briefly examined. Geometric problems relating to impacters, orbiters, and landers are reviewed. The selection of system components is discussed, and examples of designs and their properties are given. Author

N63-14739 Lockheed Missiles and Space Co., Sunnyvale, Calif.

ANNOTATED BIBLIOGRAPHY OF LUNAR PROPERTIES, GEOLOGY, VEHICLES, AND BASES. PART III: LUNAR AND ARCTIC EXPLORATION AND HABITATION

A. A. Beltran, J. B. Goldmann, and E. E. Graziano, comps. Feb. 1962 355 p 813 refs

(Spec. Bibl. SB-61-67, AD 273-136)

Part III, the final part of the lunar bibliography, is concerned with fixed and mobile lunar bases, construction problems, lunar surface vehicles, methods and feasibility of human habitation

establishment of lunar colonies, and ground support equipment. Arctic and Antarctic exploration, including base construction, surface vehicles, clothing and equipment, and environmental effects on man is included because of its applicability to lunar bases and exploration. Author

N63-14855 Manchester U. (Gt. Brit.)
STUDIES IN LUNAR TOPOGRAPHY, NO. 9. (LUNAR SHADOW MEASURING TECHNIQUES AND TABULATED RESULTS FOR THREE CRATERS) Technical Note No. 2
T. W. Rackham. May 8, 1962. 71 p
(Contract AF 61(052)-496)

The first part of this paper is concerned with methods of assessing the lengths of lunar shadows derived from microdensitometric tracings. Errors arising from atmospheric image distortion and positional uncertainties are discussed. The latter part of this work contains tabulated topographical data for the craters Tycho, Copernicus, and Theophilus. Author

N63-14984 Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
UTILIZATION OF EXTRATERRESTRIAL RESOURCES Seminar Proceedings, Sept. 25-26, 1962
Apr. 1, 1963. 38 p. 28 refs. Presented at the Meeting of the Working Group on Extraterrestrial Resources, Wash., D. C., Sept. 25-26, 1962
(NASA Contract NAS7-100)
OTS: $3.60 ph, $1.34 mf

CONTENTS:

1. STATUS OF DESIGNS OF LUNAR SURFACE VEHICLES. P. H. Bliss (RAND Corp.) p. 1-9. 4 refs. (See N63-14985 11-29)
2. HYDROPONICS OR SOILLESS CULTURE. H. D. Chapman (California U.) p. 10-15. 18 refs. (See N63-14986 11-29)
3. PROCESSING OF WATER ON THE MOON. A. A. Fowle (Arthur D. Little Co.) p. 16-18. (See N63-14987 11-29)
4. LUNAR BASE CONSTRUCTION. G. W. Johnson (Jet Propulsion Lab.) p. 19-20. (See N63-14988 11-29)
5. LUNAR ROCKS AS A SOURCE OF OXYGEN. H. G. Poole (Colorado School of Mines) p. 21-25. (See N63-14989 11-29)
6. WATER IN LUNAR MATERIALS. Robert C. Speed (Jet Propulsion Lab.) p. 26-32. 6 refs. (See N63-14990 11-29)
7. SUMMARY OF APOLLO AND LUNAR LOGISTICS SYSTEM PLANS. W. B. Taylor (NASA) p. 33. (See N63-14991 11-29)

N63-14985 RAND Corp., Santa Monica, Calif.
STATUS OF DESIGNS OF LUNAR SURFACE VEHICLES
P. H. Bliss. *In* Jet Propulsion Lab., Calif. Inst. of Tech. Utilization of Extraterrestrial Resources. Seminar Proceedings, Sept. 25-26, 1962. Apr. 1, 1963. p. 1-9. 4 refs. (See N63-14984 11-29) OTS: $3.60 ph, $1.34 mf

The designs of several lunar surface vehicles are discussed with regard to their type, size, type of traction, and motive power. A description of their body styles, and accessory provisions and performance details, where available, are presented. D. E. R.

N63-14987 Little (Arthur D.) Inc., Cambridge, Mass.
PROCESSING OF WATER ON THE MOON
A. A. Fowle. *In* Jet Propulsion Lab., Calif. Inst. of Tech. Utilization of Extraterrestrial Resources. Seminar Proceedings, Sept. 25-26, 1962. Apr. 1, 1963. p. 16-18. (See N63-14984 11-29) OTS: $3.60 ph, $1.34 mf

The processing of water by electrolysis and liquefaction are reviewed for lunar applications. It is shown that a great deal of research is needed to develop lightweight, efficient, reliable systems for the processing of water to liquid hydrogen and oxygen to define the characteristics of a near-optimum system. D. E. R.

N63-14989 Colorado School of Mines, Golden
LUNAR ROCKS AS A SOURCE OF OXYGEN
H. G. Poole. *In* Jet Propulsion Lab., Calif. Inst. of Tech. Utilization of Extraterrestrial Resources. Seminar Proceedings, Sept. 25-26, 1962. Apr. 1, 1963. p. 21-25. (See N63-14984 11-29) OTS: $3.60 ph, $1.34 mf

A thermodynamic study of the thermal stability of conventional terrestrial minerals in a hypothetical lunar atmosphere has led to the speculation that quartz and other silicates would decompose to form spinels and other alumina-bearing materials under lunar atmospheric conditions. But the spinel crust should be superficial, according to pressure studies. If quartz persists at moderate depths, it could be mined and used as a source of oxygen to support life on the moon. The same hypothesis holds for other oxides. D. E. R.

N63-14990 Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
WATER IN LUNAR MATERIALS
Robert C. Speed. *In its* Utilization of Extraterrestrial Resources Seminar Proceedings, Sept. 25-26, 1962. Apr. 1, 1963. p. 26-32. 6 refs. (See N63-14984 11-29) OTS: $3.60 ph, $1.34 mf

Evidence suggests that the materials which formed the moon were not anhydrous. Meteorites contain water, in varying amounts, as well as silicate hydrates. Water should reach the moon by gas emission just as it reaches the earth's surface. The water could possibly occur in crystalline hydrates, glasses, adsorbed water, pore water, and surface condensates. Several methods of exploration for lunar water are suggested, including spectral analysis from an orbiting vehicle, ground-based geophysical surveys, neutron albedo, qualitative indicators of hydrous rocks, and conventional petrologic instrumentation. D. E. R.

N63-15077 Arizona U., Lunar and Planetary Lab., Tucson
COMMUNICATIONS OF THE LUNAR AND PLANETARY LABORATORY, VOLUME I, NUMBERS 17-23
Gerard P. Kuiper and Alika K. Herring. 1962. 68 p. 147 refs. For Vol. I, Nos. 7-10 see N62-16618 17-28, for Vol. I, No. 11 see N62-16699 17-28, for Vol. I, Nos. 12, 13 see N62-16619 17-28, and for Vol. I, Nos. 14, 16 see N63-14008 09-05
(NASA Grant NsG-161-61)
OTS: $6.60 ph, $2.24 mf

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1. PHOTOMETRIC STUDIES OF ASTEROIDS. IX. ADDITIONAL LIGHT-CURVES. D. Owings (Indiana U.) and T. Gehrels. p. 129-146. 146 refs. (See N63-15078 11-05)
2. PHOTOMETRIC STUDIES OF ASTEROIDS. X. H. J. Wood (Indiana U.) and G. P. Kuiper. p. 147-153. 4 refs. (See N63-15079 11-05)
3. PRELIMINARY DRAWINGS OF LUNAR AREAS. III. A. K. Herring. p. 154. (See N63-15080 11-05)
4. THE COMPOSITION ANOMALIES OF 3 CENTAURI. A. S. Bashkin and B. M. Middlehurst. p. 155-159. 36 refs. (See N63-15081 11-05)
5. SURFACE PHOTOMETRY OF EXTENDED IMAGES. B. M. Middlehurst. p. 161-165. 58 refs. (See N63-15082 11-05)
6. THE WAVELENGTH DEPENDENCE OF POLARIZATION. T. Gehrels and T. M. Teska. p. 167-177. 25 refs. (See N63-15083 11-05)
7. INFRARED SPECTRA OF STARS AND PLANETS. II. WATER VAPOR IN OMICRON CETI. G. P. Kuiper. p. 179-188. 2 refs. (See N63-15084 11-05)

N63-15080 Arizona U., Lunar and Planetary Lab., Tucson
PRELIMINARY DRAWINGS OF LUNAR LIMB AREAS. III
Alika K. Herring. *In its* Communications of the Lunar and Planetary Laboratory, Vol. I, No. 19, Sept. 25, 1962. p. 154. (See N63-15077 11-05) OTS: $6.60 ph, $2.24 mf

Preliminary drawings of the limb areas of the moon are presented as a supplement to the photographic *Rectified Lunar Atlas*

Preliminary drawings of areas 10 and 16 which contain the Otto Struve and the Mare Orientale are included along with rectified photographs and key charts of the areas A stereoscopic drawing of the Mare Orientale is reproduced to emphasize the several concentric fault scraps that have this basin as their center R C M

N63-15223 Manchester U (Gt Brit)
RESEARCH INTO METHODS OF DETERMINING THE RELATIVE HEIGHTS OF PHYSIOGRAPHIC FEATURES OF THE MOON Annual Summary Report No. 1
Zdeněk Kopal Nov 1962 20 p refs
(Contract AF 61(052)-524)
(AFCRL-63-406)

Progress reported in lunar selenography includes: (1) redetermination of the libration constants of the moon; (2) evaluation and measurement of the Paris Observatory photographic plates of the moon (obtained between 1890 and 1910 and covering the full range of lunar libration) to determine the departures of the actual surface of the moon from a sphere, and (3) development of methods for the determination of small differences in height or depth of very shallow lunar surface features above or below the surrounding landscape A microrelief method is described by which topographic features less than 20 meters in height and with an inclination of less than one degree can be measured significantly by comparing the photographic density of the negative on a sloping and on a level region M P G

N63-15244 Jet Propulsion Lab , Calif Inst of Tech , Pasadena
RANGER PREFLIGHT SCIENCE ANALYSIS AND THE LUNAR PHOTOMETRIC MODEL
A G Herriman, H W Washburn, D E Willingham Jan 7, 1963, Revised Mar 11, 1963 40 p 11 refs For document before revision see N63-13449 08-29
(NASA Contract NAS7-100)
(JPL-TR-32-384, Rev) OTS $3 60 ph, $1 40 mf

A photometric model of the lunar mare surface is presented The lighting parameters for the Ranger 3, 4, and 5 TV system are developed using the photometric model and related to the system parameters The interactions of the TV constraints with those imposed by the other experiments and by trajectory characteristics are discussed in detail, and the use of plastic spheres to show graphically the interrelationships among the parameters is described Author

N63-15251 California U Berkeley Space Sciences Lab
FAULT MECHANICS OF THE LUNAR STRAIGHT WALL AND THE NATURE OF MARE MATERIAL
Robert G Strom Jan 1963 21 p 15 refs
(NASA Grant NsG 145-61)
(*Its* Ser 4, Issue 8) OTS $2 60 ph, $0 83 mf

The principles of fault mechanics are applied to the Straight Wall in order to delimit the nature of the mare material in its vicinity The magnitude of the components of displacement and the gross mechanical properties of the fractured material are derived Movement along the Straight Wall fault resulted in a maximum crustal lengthening of about 345 meters The hade (θ) of the Straight Wall is approximately 43 hence the coefficient of internal friction (μ) and the ratio (n) of the compressive-to-tensile strength of the material is about 0 059 and 1 14, respectively The large hade (θ) and small values of μ and n accord with the mechanical properties of a very weak material whose average compressive strength is probably less than 600 kg cm^2 Further, this low mechanical strength must persist to a depth equivalent to the vertical displacement of the fault, that is, to a depth of at least 200-300 meters This indicates that the mare material does not possess a strength comparable to terrestrial granites or dense basalts The materials most likely to account for the gross mechanical properties are (1) extremely porous, low density lava flows primarily consisting of rock froths (reticulite or scoria), (2) very porous tuffs or semi-welded ignimbrites, or (3) a combination of (1) and (2) Recent radiometric, photometric, and polarimetric investigations offer corroborative evidence supporting the results of the present study Author

N63-15270 New York U Coll of Engineering, N Y
PRODUCTION OF OXYGEN FROM SPACE MINERALS
E R Kaiser, J Tolciss, and Kurt Komarek Feb 1, 1963 42 p 47 refs
(NASA Grant NsG-9-59)
(Tech Rept 690 1) OTS $4 60 ph, $1 46 mf

CONTENTS
1 KINETICS AND THERMODYNAMICS FOR THE REDUCTION OF SPACE MINERALS BY HYDROGEN (APPENDIX) K Komarek p A1 A14 8 refs (See N63-15271 12-07)

N63-15805 General Mills Electronics Group, Minneapolis, Minn
SPUTTERING EFFECTS ON THE MOON'S SURFACE Fourth Quarterly Status Report, Jan. 18-Apr. 17, 1963
G K Wehner Apr 17, 1963 29 p 45 refs Submitted for Publication
(NASA Contract NASw-424)
OTS: $2 60 ph, $1 07 mf

With solar-wind data, especially from Mariner II, and laboratory sputtering-yield measurements for H^+ and He^+ ion bombardment on metal, oxide, and stone targets, the sputtering rates for bodies in earth orbit around the sun are estimated to be 1 1 Å/year for Cu and 0 4 Å/year for Fe or stones The moon must have lost a layer roughly 17 cm thick in 4 5 × 10^9 years Micrometeorites must have a very limited lifetime which is of the order of 25 000 years for a micron-size particle Author

N63-15915 Jet Propulsion Lab , Calif Inst of Tech , Pasadena
LUNAR REFERENCE COORDINATES
C F Campen, Jr Dec 29, 1961 7 p
(NASA Contract NASw-6)
(JPL-TM-33-72) OTS $1 10 ph, $0 80 mf

Two distinct conventions have been defined by the International Astronomical Union General Assembly the Astronomical Convention and the Astronautical (or Cartographic) Convention The Astronomical Convention will retain the inversion of north and south on astronomical photography but will substitute the designations "right" and "left" or "leading edge" and "trailing edge" for "east" and "west" The Astronautical Convention will use the designation of "east" and "west" and latitude-longitude division, as on earth, for the moon and other planets J A J

N63-15936 Cornell U Center for Radiophysics and Space Research, Ithaca, N Y
A THEORETICAL PHOTOMETRIC FUNCTION FOR THE LUNAR SURFACE
Bruce W Hapke Feb 1963 50 p 16 refs Submitted for Publication
(NASA Grant NsG-119-61)
(CRSR-138) OTS $4 60 ph, $1 70 mf

A formula which describes the observed photometric properties of the lunar surface is derived theoretically Functions for both the differential and integral brightness are obtained The model surface on which the derivation is based consists of a semi-infinite, porous layer of randomly-placed, obscuring objects, these objects are suspended in depth in such a manner that the interstices which separate them are interconnected A layer of fine, loosely-compacted dust is in the category of surfaces described

by this model, but volcanic foam is not. The shape of the photometric curve depends on the fractional void volume. Bulk densities of the order of one-tenth that of solid rock are implied for the upper layers of the surface of the moon. Author

N63-16189 Stanford Research Inst., Menlo Park, Calif.
ANALYSIS OF ROCKS AND MINERALS BY REFLECTED INFRARED RADIATION
R. J. P. Lyon and Eugene A. Burns. Repr. from Econ. Geol., v. 58, 1963 p 274-284. 17 refs.
(NASA Contract NASr-49(04))

This paper deals with the reflected infrared analysis of several common minerals, rocks, and meteoritic materials. The optical principles involved, and the typical spectra to be obtained from quartz plates, fused silica, and glasses are briefly reviewed, and *recent spectral data from minerals and rocks are examined*. Similarities and differences between absorption and reflection spectra for the same materials are discussed, and some of the problems encountered in the calculations of composition (modal analysis) are indicated. Applications to nondestructive testing of polished rock surfaces (or gems) and to the calculation of ambient-temperature emissivity curves for rocks are shown. Such spectral emissivity curves are an important prerequisite for the remote mapping of the lunar and other planetary surfaces. Author

N63-16190 California U., Berkeley. Space Sciences Lab.
THE CRATERS IN THE LUNAR WALLED PLAIN PTOLEMAEUS
Ann Palm and Robert G. Strom. Repr. from Planet. Space Sci., v. 11, 1963 p 125-134. 12 refs.
(NASA Grant NsG-145-61)

Diameters of craters in the lunar walled plain Ptolemaeus and in vicinal equal-area terrae (highland surfaces) were measured by means of some of the best lunar photographs available at this time. Statistical analyses of the data lead to the conclusion that the ghosts, which are partially submerged craters, and the post-Ptolemaean craters came from distinctly different populations. A range of relative rates of formation of the two types of craters was deduced from areal densities and assumed times of terminal flooding, which represents a logical fiducial point. Since Ptolemaeus is presumably an ancient feature, the rate of formation of the early ghosts exceeded the subsequent rate at which the post-Ptolemaean craters were produced by one or two orders of magnitude. On the basis of the relative surface densities, age, and frequency distributions of the total Ptolemaean and adjacent terrae craters, it is tentatively inferred that these craters may have had a similar history. Author

N63-16246 Harvard Coll. Observatory, Cambridge, Mass.
A NEW PROGRAM OF PLANETARY PHOTOGRAPHY
D. H. Menzel [1963] 1 p. Repr. from Mem. Soc. R. Sc. Liège, 5th ser., v. 7, 1963 p 115. Presented at the 11th Intern. Astrophysical Symp., Liège, July 9-12, 1962
(NASA Grant NsG-89-60)
(*Its* Reprint 616)

Harvard College Observatory, under NASA sponsorship, has initiated a three-year program for multicolor photometry of the Moon, Mars, Venus, and other planets. The studies are being undertaken with a new 16-inch Cassegrain reflector at Boyden Observatory in South Africa and with the 12-inch reflector at the Le Houga Observatory in Southern France. Three dozen comparison stars have been selected, some are of zero color index, some of index +1, and others are of the solar type. A special lens gives an *image of the Moon on a scale roughly matching that of the planets*. J A J

N63-16254 Manchester U. (Gt. Brit.)
LUNAR PHOTOMETRIC AND TOPOGRAPHICAL ANALYSIS Annual Summary Report No. 2, July 1, 1961-June 30, 1962
I. W. Rackham. Oct. 1962. 12 p. 2 refs.
(Grant AF EOAR 61(052)-496)

This report outlines the activities of the Manchester Lunar Photographic Team at the Pic du Midi Observatory during the period 1 July 1961 to 30 June 1962. Author

N63-16459 Rochester U., N.Y.
ESTIMATE OF NEUTRON ALBEDO ON THE MOON'S SURFACE DUE TO COSMIC RAY BOMBARDMENT
M. V. Krishna Appa Rao. May 17, 1963. 6 p. 6 refs. Submitted for Publication
(Contract AT(30-1)-875)
(NYO-10265)

An estimate based on calculations made for chrondrite and basalt rocks, which probably constitute the moon's surface, is presented for the neutron albedo on the moon's surface due to cosmic radiation. The total neutron albedo for the top 1 c.c. of the moon's surface, assuming basaltic composition, was calculated to be 2.12×10^{-2}/sec. To obtain the total number of neutron albedo from a column of 1 c.c., multiplication of the above number by the free path of neutron absorption in the rock, which was calculated to be approximately 8 cm, was performed. The neutron albedo due to the interaction of protons and helium nuclei was then calculated and totaled, thus giving the total neutron albedo of 0.26/sec cm^2 for basaltic rock. The corresponding value for chrondritic rock was calculated to be 0.35/sec cm^2. N E A

N63-16513 Manchester U. (Gt. Brit.)
LUNAR INFRA-RED MEASUREMENTS Technical Note No. 2
R. Sternberg. Oct. 1962. 67 p.
(Contract AF 61(052)-400)
(AFCRL-63-459)

Following the successful development of techniques for producing multilayer interference filters for the infrared out to 20μ, a radiometer was designed and constructed to make observations of the moon in the atmospheric window 8μ to 13μ, using the 50-inch telescope at Asiago. The primary aim was to use this instrument to determine the emissivity of the lunar surface by measuring the radiant flux from the moon in two or more narrow spectral regions within this band. Due to unusually unfavorable weather conditions during the first expedition, this objective could not be achieved. However, a number of anomalous temperature distributions were found, which appear to be associated with ray craters. Author

N63-16702 California Inst. of Tech., Div. of Geological Sciences, Pasadena
THE STABILITY OF VOLATILES IN THE SOLAR SYSTEM
Kenneth Watson, Bruce Murray, and Harrison Brown. Repr. from Icarus, v. 1, no. 4, Jan. 1963 p 317-327. 18 refs.
(NASA Grant NsG-56-60)

The previous study of the stability of ices of common volatiles (water, ammonia, carbon dioxide, and methane) on the surface of the moon has been extended to other surface environments in the solar system. A spherical body composed of a mixture of these ices is considered; initially considered is the stability of such spheres at heliocentric distances of 1 to 10 a.u. These results are then applied to an examination of the stability of ices in the rings of Saturn, on the surfaces of the smaller satellites of Jupiter and of Saturn, and finally to bodies in orbits similar to those of short period comets. Author

N63-16731 Cornell U. Center for Radiophysics and Space Research, Ithaca, N.Y.
STRUCTURE OF THE MOON'S SURFACE
T. Gold Apr. 1963 11 p Presented at the Am. Geophys. Union, Apr. 1963 Submitted for Publication
(NASA Grant NsG-382)
(NASA-CR-50117; CRSR-140) OTS: $1.60 ph, $0.80 mf

This report describes the moon's surface as consisting of fine powders (fluffy material). The generation of this fluffy surface material should be thought of as connected with local processes on the surface rather than with a general blanketing by micrometeorites or by volcanic ash or by all the ray material ejected from all the craters. For in all the cases of general blanketing, no explanation would remain for the characteristic color differentiation whereby the high ground is generally lighter than the low ground. The conclusion that both ought to be the same color because they are the same material can be avoided if the underdense surface is generated, at least in part, from local "stuff" rather than from a general blanket. I.v.L.

N63-16987 National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, Ala.
ASCENT FROM THE LUNAR SURFACE
Rowland E. Burns and Larry G. Singleton Washington, NASA, June 1963 155 p 5 refs
(NASA TN D-1644) OTS: $3.00

The problem of three-dimensional optimal ascent from the lunar surface is discussed using the techniques of variational calculus. The moon is assumed to be spherical and rotating, perturbational effects from all other bodies are neglected. Final orbital inclination is calculated under the assumption that the angular displacement of the moon during ascent is negligible. Only single-stage vehicles are considered, and are subdivided into propellant and mass in orbit. Both thrust and mass-flow are assumed constant throughout the powered flight of a given vehicle. The technological range considered covers specific impulse values of 300 sec to 450 sec (in steps of 50 sec), and lunar thrust-to-weight ratios of 1 to 7 (in steps of 1). Initial lift-off angles vary from 0° to 40° (in steps of 10°). Most results assume a launch site on the lunar equator at the lunar prime meridian, and a final orbital inclination of 5°. In each case, the thrust and velocity vectors are alined at cutoff. Sample cases deal with launch latitudes of 30° and 60°, while other calculations show the effects of varying final inclination from 0° to 180°. The results present mass fraction in orbit and final orbital altitudes as well as the initial values of certain mathematical functions (Lagrange multipliers) necessary to attain these end conditions. Optimum values of initial thrust-to-weight ratios and orbits of maximum mass fraction are described for each combination of specific impulse and lift-off angle. These results are presented both tabularly and graphically; several examples illustrate applications to preliminary design studies. Author

N63-17108 National Aeronautics and Space Administration Goddard Space Flight Center, Greenbelt, Md.
EVIDENCE FROM THE MOON'S SURFACE FEATURES FOR THE PRODUCTION OF LUNAR GRANITES
John A. O'Keefe and Winifred Sawtell Cameron *In its* Goddard Space Flight Center Contributions to the COSPAR Meeting, May 1962 May 1963 p 61-83 40 refs Submitted for Publication (See N63-17105 15-29) OTS: $3.50

The evidence for granitic rocks from the morphology of the moon's surface is considered in this paper. The displacement of the center of the moon's visible surface with respect to the center of mass is considered evidence of isostasy on the moon. It is shown that this displacement is not merely a limb phenomenon, and is probably not explicable in terms of the kind of lumpy interior proposed by Urey to explain the differences of the moments of inertia. Evidence for characteristic granite topographic features, including tholoids and laccoliths, is summarized. The possibility that the maria were produced by the fluidization of volcanic ash is considered. The transporting fluid is considered to be the contained gases as in a terrestrial ash flow. Ash flows on the earth are responsible for the emplacement of a large fraction of all volcanic ash. From a study of the physics of ash flows, it is determined that the fluidization should be even more effective on the moon. It is concluded that the morphology of the moon's surface does not contradict the notion that large amounts of acid rock are present on its surface. Author

N63-17133 California Inst. of Tech. Div. of Geological Sciences, Pasadena
SURFACE TEMPERATURE VARIATIONS DURING THE LUNAR NIGHTTIME
Bruce C. Murray and Robert L. Wildey May 17, 1963 45 p 30 refs Submitted for Publication
(NASA Grant NsG-56-60)
(NASA CR-50148) OTS: $4.60 ph, $1.55 mf

Observations of the 8- to 14-micron thermal emission into the first 160 hours of the lunar nighttime of the moon are described in full. The evidence of both horizontal and vertical variations in thermal properties of the lunar surface is discussed. It is also pointed out that these observations, along with other recent radar observations, are strongly suggestive of surface redistribution processes presently active on the lunar surface. N.E.A.

N63-17204 General Mills Electronics Group, Minneapolis, Minn.
SPUTTERING EFFECTS ON THE MOON'S SURFACE Third Quarterly Status Report, Oct. 18, 1962-Jan. 17, 1963
G. K. Wehner Jan. 30, 1963 27 p 17 refs
(NASA Contract NASw-424)
(NASA CR-50229; Rept. 2364) OTS: $2.60 ph, $1.01 mf

Sputtering yields of various terrestrial rocks under Hg^+-ion bombardment of several hundred ev energy were determined with a high-frequency sputtering method. Yields by volume are found to be in the same range as that of Fe, a medium sputtering rate metal. Sputtering yields of metals and oxides were determined with a method where mass separated hydrogen beams (H^+, H_2^+, and H_3^+) at ~7 Kev sputter holes into thin target foils. The method and results are described in detail. Ion-bombarded powder samples produce a surface which has photometric properties which are very similar to those required from moon-surface studies. Recent literature data on the solar wind, especially from Mariner II, and our new experimental sputtering yields are incorporated in a revised table on lunar sputtering rates. Author

N63-17806 California Inst. of Tech. Seismological Lab., Pasadena
SEISMIC EXPLORATION OF THE MOON
R. L. Kovach, Frank Press, and Francis Lehner N.Y., AIAA 1963 8 p 8 refs Presented at AIAA Summer Meeting, Los Angeles, June 17-20, 1963
(NASA Contracts NASw-81 and NAS7-100)
(AIAA Paper 63-255) AIAA: $0.50 members, $1.00 nonmembers

The single axis seismometer, carried aboard the Ranger flights 3, 4, and 5, is described as containing a coil, a spring-suspended magnet, and an internal calibration device with a permanent magnet suspended from the body of the instrument acting as the seismic mass. Movement of the coil produces the transducer output. The seismic data are transmitted to

earth via telemetry signals. For other lunar missions, a new, lightweight, compact, three-component seismometer is being developed. Equipped with displacement transducers and long-term recording equipment, the instrument will transmit data on moonquakes and seismic signals from meteoric impact over long periods. Lunar seismograms are explained in theory and their value in analyzing the lunar surface and structure is explained. D.E.R.

N63-18051 Ohio State U. Research Foundation. Antenna Lab., Columbus.
THE SOLUTION OF AN INTEGRAL EQUATION FOR THE LUNAR SCATTERING FUNCTION
R. T. Compton, Jr. Apr. 1, 1963. 16 p.
(NASA Grant NsG-213-61)
(Rept. 1388-8) OTS: $1.60 ph, $0.80 mf

The problem of measuring the scattering properties of the moon with an unmodulated continuous wave radar was considered. It was assumed that the average scattering cross section per unit area of the lunar surface depended only on the angle between the direction of incidence and the normal to the surface. With this assumption, it was possible to calculate the scattering function from the power density spectrum of the echo signal. The scattering function was found as the solution to an Abel type integral equation. I.v.L.

N63-18219 National Aeronautics and Space Administration, Washington, D.C.
WE KNOW SO SHAMEFULLY LITTLE ABOUT THE MOON
Howard Simons (Washington Post). Repr. from the Washington Post. 8 p.
GPO: $0.50

The moon is discussed from the standpoint of origin, and its topography. The dissenting views on lunar dust vs. lava flows in the dark areas of the maria and the volcanic vs. meteoritic origin of the craters are elaborated upon. J.A.J.

N63-18290 Columbia U., Lamont Geological Observatory, Palisades, N.Y.
DESIGN AND CONSTRUCTION OF A LUNAR SEISMOGRAPH Progress Report, Jan. 1-Mar. 31, 1963
M. Ewing. 1963. 34 p.
(NASA Contract NASw-82)
(NASA CR-50245; Rept. 15) OTS: $3.60 ph, $1.22 mf

Preparation of design requirements for the short-period vertical seismometer to be employed as a backup instrument for early Surveyor flights is reported. A slightly modified version of the Surveyor seismograph system has been built (using other support) for use on the ocean floor. The Surveyor breadboard system is being prepared for longterm operation in a mine where a highly stable environment exists for measurement of earth tides. Author

N63-18291 California Inst. of Tech., Div. of Geological Sciences, Pasadena
NEW MEASUREMENTS OF STEEP LUNAR SLOPES
Howard A. Pohn. Jan. 7, 1963. 4 p. Submitted for Publication.
(NASA Grant NsG-59-60)
(NASA CR-50096) OTS: $1.10 ph, $0.80 mf

The UBV (ultraviolet blue visual) investigations of the moon from phase angles of $-25°$ to $+25°$, using the Mount Wilson 60-in. telescope are discussed. A group of 19 craters was selected so as to give a maximum distribution in latitude and longitude. These objects ranged in size from approximately 5 km to more than 90 km. The presence or absence of shadows cast by the interior walls of these craters was noted, over several runs, and the sun's altitude over the object later computed. The sun's altitude is given, it yields directly a minimum value of the steepness of slopes casting a shadow at the time of observation. While some craters were seen to be shadowed over several runs, only the highest sun's altitude is presented. The average value for the observations was 37° 15', and this value includes all of the craters without regard to their selenographic longitudes. N.E.A.

N63-18322 New Mexico U., Engineering Experiment Station, Albuquerque
AN APPROACH TO CORRELATE PULSED RADAR AND PHOTOGRAPHIC DATA
Nasir Ahmed and W. W. Koepsel. [1960] 71 p. 15 refs.
(NASA Grant NsG 129-61)
(NASA CR-50536, EE-89) OTS: $7.60 ph, $2.33 mf

This work describes an approach to the study of correlation between pulsed radar and photographic data, as a method of supplementing the available statistical information on area-extensive radar scattering surfaces. A measure of the scattered energy is obtained by studying the variance and power spectra of the radar and photographic data. These spectra are obtained by taking the Fourier transform of the respective autocorrelation functions obtained from the radar and photographic data. Therefore, the variance and power spectra are considered for correlation studies. The results seem to indicate that a correlation between the radar and photographic data depends on the nature of the terrain. Author

N63-18343 Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
LUNAR STRATIGRAPHY
John B. Adams. N.Y., Am. Inst. of Aeron. and Astronautics [1963] 10 p. 10 refs. Presented at the AIAA Summer Meeting, Los Angeles, June 17-20, 1963
(AIAA Paper 63-254) AIAA: $0.50 members, $1.00 nonmembers

The principal processes of stratigraphy on the moon are meteorite impacts, erosion, transportation, and volcanism. Meteorite impacts seem to be the most likely process which will allow age determination. Erosion processes such as seismic shocks, thermal fracture, and solar and cosmic radiation, show little probability of being effective on the moon surface and therefore of little value in the study of lunar stratigraphy. Transportation is, also, an unlikely process because there is still no evidence for the existence of a mechanism to erode or transport lunar surface material. If volcanism does exist on the moon, the overlapping of newer flows on older ones would be an important process in the stratigraphic recording of lunar history. P.V.E.

N63-18371 RAND Corp., Santa Monica, Calif.
NOTES OF WORKING SYMPOSIUM ON SOLAR SYSTEM CONSTANTS, FEBRUARY 22-26, 1962
Donna Wilson, comp. May 1963. 78 p. 40 refs.
(NASA Contract NASr-21(04))
(NASA CR-50394; RM-3425) OTS: $7.60 ph, $2.54 mf

Topics covered at the Solar System Constants Symposium included the following: philosophies of approach, problem areas relative to the astronomical unit, problem areas of geodetic and geophysical constants, space experiments, earth's equatorial radius, lunar constants, planetary constants, and astronomical unit determinations. J.A.J.

N63-18395 Ohio State U. Research Foundation. Antenna Lab., Columbus, Ohio
RADAR BACK-SCATTERING MEASUREMENTS FROM "MOON-LIKE" SURFACES
W. H. Peake and R. C. Taylor. May 1, 1963. 18 p. 2 refs.
(NASA Grant NsG-213-61)
(NASA CR-50304, Rept. 1388-9) OTS: $1.60 ph, $0.80 mf

Measurements of back scattering from a number of rubble-like surfaces have been made for several polarization states. For such surfaces there is a qualitative relation between the surface roughness, and angular and polarization dependence of the back scatter. This relation may be used to estimate surface roughness, and perhaps dielectric constant, from back scattering measurements. Author

N63-18415 Stanford Research Inst., Menlo Park, Calif.
FEASIBILITY OF REMOTE COMPOSITIONAL MAPPING OF THE LUNAR SURFACE. EFFECTS OF SURFACE ROUGHNESS
Eugene A. Burns (Space Technol. Labs.) and R. J. P. Lyon. May 23, 1963. 24 p. 17 refs.
(NASA Contract NASr-49(04))
(NASA CR-50544) OTS: $2.60 ph, $0.92 mf

Consideration of an instrument capable of remote compositional mapping of the lunar surface by measurement of the diagnostic spectral emissivity curves results in the recommendation of a modified Perkin-Elmer Model SG-4 Spectrophotometer. A discussion of the constraints imposed on the design of this instrument for spectral resolution, weight, signal-to-noise ratio, detector temperature and configuration, and power requirements is presented, together with the implications of these factors on the objectives of compositional mapping from a spacecraft. Author

N63-18422 Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
LUNAR SURFACE AND SUBSURFACE MAGNETIC SUSCEPTIBILITY INSTRUMENTATION
Edgar M. Bollin [1962] 7 p. Repr. from IRE Trans. Instr., v. I-11, nos. 3 & 4, Dec. 1962, p. 101-106. 4 refs. Presented at the 1962 International Conf. on Precision Electromagnetic Measurements
(NASA Contract NAS7-100)
(NASA CR-50578; Conf. Paper 1.5; JPL TR-32-343)

Multicoil induction measurements of the lunar surface and subsurface magnetic susceptibility are under study. Major considerations are the improvement of the accuracy and logging ability of various probe configurations. Special boundary conditions of high vacuum, extreme ambient temperature variation, restriction to mechanically passive systems, simple electronics, low power and light weight all contribute to degradation of the accuracy of the instrument. Measurements in the range of 10 to 100,000 micro-oersted/gauss are of interest. Nonsedimentary rocks range from 40 to 1000 μ-oersted/gauss, and the presence of nickel-iron meteoritic material may extend the range beyond the present limits of measurement. The determination of the presence or absence of meteoritic material is necessary to validate not only the accuracy of the susceptibility measurement, but also the accuracy of low-level magnetometer measurements. Author

N63-18448 Air Force Systems Command. Foreign Technology Div., Wright-Patterson AFB, Ohio
FIRST PHOTOS OF THE REVERSE SIDE OF THE MOON
In its Soviet Satellites and Space Ships (Selected Articles) Feb. 23, 1962. p. 159-165. (See N63-18430 17-32)

An analysis of photos of the reverse side of the moon obtained from the Automatic Interplanetary Station (AIS) is presented. As a result of preliminary investigation of available photos, it can be mentioned that on the invisible part of the lunar surface are predominant mountainous regions, and there are very few seas that are similar to the seas on the visible side of the moon. For the most part there are crater seas, lying in the southern and near-equatorial regions. Of the seas photographed on the invisible surface, but close to visible edge, are the Humboldt Sea, Marginal Sea, Smith Sea, and Southern Sea. N E A

N63-18775 California U., Berkeley. Lawrence Radiation Lab.
PROTON ACTIVATION IN SPACE VEHICLES
Paul W. Todd *In its* Biology and Medicine—Semiannual Report, Fall 1962. Dec. 1962. p. 1-14. 75 refs. (See N63-18774 17-16)
OTS: $2.75
(Supported by NASA and AEC)

Proton-induced radioactivity in the inner radiation belt has been analyzed from available experimental data in the literature prior to 1961, to estimate its relevance to spaceflight safety and instrumentation. Proton-excitation functions of carbon, nitrogen, oxygen, and aluminum are presented and used to calculate induced radioactivity in a scintillation detector, an aluminum shell, and in the "standard man." Planetary exploration apparatus is also considered. In these cases, induced radioactivity in the inner radiation belt has been found measurable but small. It presents little problem to spaceflight and exploration, but can give rise to a small increase in count rate if low-background counting is performed by specialized detecting devices. In particular, proton-induced radioactivity was found to influence a detection system designed for the determination of the potassium 40 content of the lunar surface. Author

N63-18778 Air Force Systems Command, Kirtland AFB, N. Mex.
BIBLIOGRAPHY OF EXTRATERRESTRIAL RESEARCH
Robert W. Henry. June 1963. 104 p. 1504 refs.
(AFWL-RTD-TDR-63-3025)

This bibliography on extraterrestrial research is subdivided into the following categories: Astrobiology, Astronomy and Cosmology, Cratering Phenomena, Extraterrestrial Matter, Materials, Meteoritic Cratering, Moon (Atlases and Photography, Configuration, Experimental Research, Exploration and Basing Concepts, Lunar-Earth Phenomena, Lunar Trajectories, Surface Materials, and Topographical Features), Planets, Power Systems, Space Vehicles and Probes, Tektites, and Vacuum Environmental Simulation. Author

N63-18863 National Aeronautics and Space Administration, Washington, D.C.
LUNAR EXPLORATION PROGRAM Sixth Semi-Annual Report to Congress
B. Milwitzky. Dec. 5, 1961. 19 p.
(NASA TM X-50135) OTS: $1.60 ph, $0.80 mf

The current NASA programs—Ranger, Surveyor, and Prospector—designed to provide unmanned exploration of the lunar surface are summarized. The basic objectives of the unmanned lunar exploration program are: (1) to design, develop, and utilize spacecraft and instrumentation to explore the moon by landing instrument payloads and capsules on the lunar surface and by placing scientific instruments in precise lunar orbits; (2) to carry out investigations to further our knowledge of cislunar space, the environment at the lunar surface, and the physical and chemical properties of the moon; (3) to provide information leading to an understanding of the origin and

history of the moon and solar system; and (4) to provide support to subsequent manned lunar exploration. The nine flights of the Ranger project are divided into three categories: to provide engineering data on the spacecraft systems; to rough-land a payload on the moon; and to orbit the moon, obtaining high-resolution TV pictures. The Surveyor has two spacecraft systems, a soft-lander and an orbital craft. The Prospector will pick its landing site, soft-land, and provide roving exploration of the lunar surface and support of manned landings. D.E.R.

N63-18921 Sophia U. (Bulgaria)
AN INSTANCE OF REACTION MOTION IN NATURE [SUR UN CAS DE MOUVEMENT À RÉACTIONS DANS LA NATURE]
N[ickola] Bonev *In* Assoc. Intern. Uomo nello Spazio, Rome Proc. of the Intern. Cong.—Man and Technol. in the Nucl. and Space Age, Milan, Apr. 18–21, 1962 p 139–142 10 refs (See N63-18914 18-01)

The formation of craters on the lunar surface is discussed. One belief is that these craters resulted from eruptions on the moon, another belief is that the craters were formed by meteor bombardment. This latter hypothesis of meteor bombardment seems to be held in a more favorable position than the belief that the craters were formed by volcanic eruptions. C.L.W.

N63-19354 Aerospace Information Div., Library of Congress, Washington, D.C.
LUNAR DIMENSIONS. ANNOTATED BIBLIOGRAPHY OF SOVIET-BLOC LITERATURE, 1957-1963
July 30, 1963 58 p 68 refs
(AID Rept. B-63-100) OTS: $5.60 ph, $1.94 mf

N63-19488 Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
THE IMPORTANCE OF MANNED LUNAR EXPLORATION An Open-End Discussion
A. R. Hibbs, Moderator *In* North American Aviation, Inc., Downey, Calif. Proc. of the Lunar and Planetary Exploration Colloq., Santa Monica, Calif., May 23-24, 1962 p 87-98 (See N63-19478 19-16)

It appears that sending a man to the moon on the first exploratory trips would be of negligible value. He could do little more than an instrument in collecting preliminary data, geological and, possibly, biological samples from the lunar surface and returning them to earth for processing and evaluation. Once this preliminary information on the lunar environment is available, however, a man, or men, should go there to make firsthand observations, gather additional data and samples and conduct experiments that would be too sophisticated for an instrument or automation. Author

N63-19541 Aeronutronic, Newport Beach, Calif.
THE RANGER LUNAR CAPSULE
Frank G. Denison *In* Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena Ranger Program Repr. from Astronautics, Sept. 1961 p 32-33 and p 77-78 (See N63-19535 19-32)

The design and operation of the Ranger lunar capsule, designed to place a sterile seismometer and related equipment on the moon's surface, is described. The capsule is carried to the immdeiate vicinity of the moon by the Ranger bus. A fuze-type altimeter in the capsule measures the distance to the moon and, at a predetermined altitude from the lunar surface, signals for bus-capsule separation. A retrorocket brakes the capsule landing sphere as it falls to the lunar surface. The landing sphere contains the impact limiter and a fluid-floated survival sphere with its scientific instrumentaion. Upon arrival at the lunar surface, the survival sphere automatically erects itself to local vertical by means of lunar gravity. This vertical positioning of the sensitive axis of the seismometer permits the use of a modestly directional transmitting antenna to relay scientific and engineering data back to the Deep Space Instrumentation Facility. The seismometer is designed not only to provide a record of moonquakes and meteoric impacts, should they occur, but also to record the continuous, microscopic seismic motions that are believed to exist on the moon. M.P.G.

N63-20192 Texas Instruments, Inc., Dallas
EVALUATION OF LUNAR GRAVITY NEEDS AND GRAVITY METER CAPABILITIES Final Report
F. E. Romberg et al. July 5, 1963 94 p 46 refs
(NASA Contract NASw-581)
(NASA CR-50772) OTS: $8.60 ph, $3.02 mf

The use of gravity meters on the moon to provide data and information concerning earth-caused tides, due to the moon's monthly change in orbital distance from the earth, is discussed. Gravity meters, equipped with properly constructed readout devices, could also act as seismometers and provide data as to the moon's seismicity. Gravity meter design and methods of implementation are examined, and it is concluded that gravity can play an important role in all stages of lunar exploration and that the gravity meter best adapted to present transport in a hard landing lunar spacecraft is one based on a quartz elastic member. This instrument is so far advanced in testing and development that it can reasonably be expected to be successful. C.L.W.

N63-20246 Bellcomm, Inc., Washington, D.C.
LUNAR SURFACE CHARACTERISTICS
R. F. Fudali June 25, 1963 (rev.) 31 p 31 refs
(NASA Contract NASw-417) OTS: $3.60 ph, $1.13 mf

Experimental evidence indicates that the lunar atmosphere may be considered essentially nonexistent, and that lunar surface temperatures vary from 390 ±20° K to 110 ±25° K for regions exposed to the sun during a lunation. Temperature variations are shown as a function of both phase angle and latitude. Large-scale surface features are briefly described, and small-scale relief is inferred from the large-scale features and a consideration of possible modes of origin. An estimate of the average radioactivity dose due to surface material (3 millirems/week) is much less than that considered hazardous. The surface is both a poor thermal and electrical conductor, but the vertical extent of this insulating material is unknown. Author

N63-20249 New Mexico U., Albuquerque Engineering Experiment Station
BIBLIOGRAPHY OF BACKSCATTER AND RELATED SUBJECTS
Donald H. Lenhert, Nasir Ahmed, W. W. Koepsel, and B. D. Warner June 1963 43 p 549 refs
(NASA Grant NsG-129-61)
(NASA CR-50856; EE-92) OTS: $4.60 ph, $1.49 mf

Several major topic areas are included in this bibliography. These areas are: (1) backscatter and radar return, (2) lunar surface properties, (3) acoustic instrumentation and simulation of radar return from terrain and geometrical shapes, and (4) correlation of radar and photographic data. A list of references which resulted from this research and the associated literature searches is compiled. Author

N63-21044 IIT Research Inst., Chicago, Ill.
STUDIES OF LUNAR SOIL MECHANICS Final Report
E. Vey and J. D. Nelson July 1963 100 p 57 refs
(NASA Contract NASr-65(02)
(NASA CR-50930) OTS: $8.60 ph, $3.20 mf

To provide basic engineering data on the behavior of soils under lunar environmental conditions, experiments were performed to determine the properties of soils under atmospheric pressures and vacuum levels up to the 10^{-10} torr range. Experiments consisted primarily of the determination of the vacuum in soil pores in relation to chamber vacuum, the porosity attained by deposited soil, shear-strength parameters, and load-settlement relationships on small loaded areas. It was observed that the vacuum in the soil pores was considerably less than that recorded in the chamber. Porosities attained by soil deposited under low vacuums (1 to 10^{-3} torr) were less than those attained in atmosphere. But at higher vacuum levels the porosity increased with an increase in vacuum, and in the case of silica flour, for vacuums of 10^{-7} torr or higher, it was greater than when deposited in atmosphere. Direct shear tests showed that the apparent cohesion and the internal friction of the silica flour increased under vacuum. This was also evidenced by increased bearing capacity. The increase in porosity in soils, and the effects on the apparent cohesion, were attributed to the development of interparticle forces. These forces may be either attractive or repulsive depending on the mineralogical composition of the soil and the vacuum level. Author

N63-21111 General Mills, Inc., Minneapolis, Minn. Electronics Div.
INVESTIGATION OF SPUTTERING EFFECTS ON THE MOON'S SURFACE First Quarterly Status Report, 25 Apr.-24 July 1963
G. K. Wehner, D. L. Rosenberg, and C. E. Ken Knight. July 31, 1963. 22 p. 11 refs.
(NASA Contracts NASw-751 and NASw-424, Proj. 89308)
(NASA CR-51082, Rept. 2414) OTS: $2.60 ph, $0.86 mf.

Long-duration solar-wind sputtering conditions were simulated at at a much accelerated scale with mass-separated hydrogen-ion beams, or in low-pressure, noble-gas or hydrogen plasmas. Experiments with metal targets and metal-, oxide-, and rock-powder samples demonstrate the leveling and smoothing of macroscopic surface features, and cementing together of loose particles into a porous, brittle, fibrous crust. Certain oxide surfaces become enriched with metal atoms under the bombardment and sputtering action. It is concluded that many of the unusual properties of the lunar surface can be explained by the action of solar-wind bombardment. Author

N63-21346 Virginia Polytechnic Inst., Blacksburg
LUNAR EXPLORATION. PROCEEDINGS OF THE CONFERENCE ON LUNAR EXPLORATION, PART C – AUGUST 12-17, 1962
Oran W. Nicks et al. Aug. 1962. 169 p. 52 refs. Repr. from Bull. Eng. Expt. Sta., v. 56, no. 7, May 1963.
(Supported by NASA and NSF)
(*Its* Eng. Expt. Stat. Series 152)

The following topics dealing with lunar exploration were discussed: (1) photography of the moon from space probes, (2) lunar seismology, (3) prospects for the existence of lunar organic matter, (4) instrumentation for lunar soft landings and (5) the nature of the lunar surface and major structural features. P.V.E.

N63-21361 Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
THE DEVELOPMENT OF THE SURVEYOR GAS CHROMATOGRAPH
W. F. Wilhite. May 15, 1963. 19 p. 3 refs.
(NASA Contract NAS7-100)
(NASA CR-51007, JPL-TR-32-425) OTS: $1.60 ph, $0.80 mf.

The instrument is designed to be soft-landed on the surface of the moon as part of the Surveyor scientific payload. While on the lunar surface, the gas chromatograph should provide an analysis of the volatile constituents in a sample of the lunar surface material. The report discusses provisions for thermal control of the operating instrument over a wide range of ambient temperatures, packaging necessary to meet the severe vibration and temperature environments, and problems encountered in the design of subassemblies of the instrument, such as solid sample handling and heating in the oven subassembly, programed valving, column materials, sample detection, signal processing, and calibration. Author

N63-21362 Virginia Polytechnic Inst., Blacksburg
CONFERENCE ON LUNAR EXPLORATION PART B. PROCEEDINGS AUGUST 12-17, 1962
J. V. Evans, T. B. A. Senior, Eugene Shoemaker, Jack Green, and Wernher von Braun. Aug. 1962. 202 p. 101 refs.
(Supported by NASA and NSF)
(*Its* Bulletin, Eng. Expt. Sta. Series no. 152, v. 56, no. 7, May, 1963)

This conferene on lunar exploration covers the following: radio echo studies of the moon; interpretation of lunar radar data; application of photographic photometry to the geology of the lunar surface; lunar vulcanism; and manned lunar exploration. J.R.C.

N63-21479 Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
ASTRONAUTICS INFORMATION. ENGINEERING EQUIPMENT AND PROCESSES ADAPTABLE TO LUNAR AND PLANETARY EXPLORATION
Dorothy I. Sweitzer, comp. May 1963. 340 p. 2705 refs.
(NASA Contract NAS7-100)
(NASA CR-50966; JPL-AI/LS-464) OTS: $19.75 ph, $10.40 mf.

A bibliography is given of catalog citations and abstracts on the subjects of general manipulators, roving vehicles and stationary structures, soil, vegetation, dust and particles, gas and liquid, inspection, testing, and analysis techniques, mechanisms for gripping, holding, hoisting, lowering, conveying, cutting, crushing, grinding, sweeping, and abrasive cleaning, mining equipment and techniques, machinery construction, remote, automatic, and adaptive control, and human time lag and human factors in control. J.E.T.

N63-21615 Virginia Polytechnic Inst., Blacksburg
PROCEEDINGS OF THE CONFERENCE ON LUNAR EXPLORATION, AUG 12-17, 1962
May 1963. 204 p. 105 refs.
(Sponsored by NASA and NSF)
(*Its* Bulletin, Eng. Expt. Sta. Ser. No. 152, Pt. A; Vol. 56, no. 1)
VPI: $1.00

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7. THE NATURE OF THE LUNAR SURFACE AND MAJOR STRUCTURAL FEATURES R. B. Baldwin (Oliver Mach. Co.) p VII/1-VII/38 35 refs (See N63-21622 22-29)

N63-21617 Liverpool U. (Gt. Brit.)

THE DETERMINATION OF THE MASS, SHAPE, MOMENTS OF INERTIA, AND GRAVITATIONAL FIELD OF THE MOON

P. J. Message *In* Va. Polytech. Inst. Proc. of the Conf. on Lunar Exploration, Aug. 12-17, 1962 p II/1-II/20 23 refs (See N63-21615 22-29)

The determination of the mass, shape, moments of inertia, and the gravitational field of the moon are discussed. The only means, at the present, for the determination of the mass of the moon is by the measurement of the lunar equation, i.e., the displacement in the apparent position of any member of the solar system, as observed from the earth, arising from the earth's monthly revolution about the center of mass of the earth and the moon. The shape of the surface of the moon can be determined by measurement. From the apparent movements of objects on the surface during the librations (the departures of the orientation of the moon from the configuration defined by Cassini's empirical laws), the geometrical shape of the surface can be determined. The ratios of the moments of inertia of the moon can be determined from the rigid body motions, starting with Cassini's empirical laws which describe the orientation of the moon within about 2 minutes of arc. The gravitational field of the moon can be expressed in terms of the potential V, which is given, at an exterior point, P by

$$V(P) = -\frac{Gm_{\mathbb{D}}}{r}\left\{1 - \frac{C - 1/2(A+B)}{m_{\mathbb{D}}R_{\mathbb{D}}^2}\left(\frac{R_{\mathbb{D}}}{r}\right)^2 \frac{(3\sin^2\beta - 1)}{2}\right.$$

$$\left. + 3/4\,\frac{(A-B)}{m_{\mathbb{D}}R_{\mathbb{D}}^2}\left(\frac{R_{\mathbb{D}}}{r}\right)^2 \cos 2\lambda \cos^2\beta + 0\left[\left(\frac{R_{\mathbb{D}}}{r}\right)^3\right]\right\}$$

where A, B, C are the principal moments of inertia of the Moon, $R_{\mathbb{D}}$ its mean radius, r is the distance of P from the center of mass, and λ and β the longitude and latitude of P referred to the Moon's equator. I.v.L.

N63-21618 California U., La Jolla Inst. of Tech. and Engineering

AGE OF THE MOON, CHEMICAL COMPOSITION, GEOLOGICAL ASPECTS, STRESS AND COOLING HISTORY

Harold C. Urey *In* Va. Polytech. Inst. Proc. of the Conf. on Lunar Exploration, Aug. 12-17, 1962 p III/1-III/31 8 refs (See N63-21615 22-29)

The moon probably formed 4.5 billion years ago in a melted state. The surface temperature would have started at about 1100° C and cooled throughout its history. This situation exists for all radial stations within the moon, but with a more rapid and greater degree of cooling being apparent near the surface. At the center of the moon, very little cooling will have occurred through diffusivity during the 4.5 billion years of its existence. The variation of temperature with depth (or radius) follows the quadratic temperature variation through the moon itself. Should there be any radioactive heating in the interior, then the temperature will necessarily be increased. Temperatures of the order of 2500° to 2800° C, as a maximum, might be expected in the interior, dependent on the choice of potassium abundance. The moon's irregular shape is due to bulges toward and away from the earth. These bulges are estimated to be about one kilometer in height, whereas the equilibrium height of the moon would be about 60 meters. Hence, the bulge could be accounted for by assuming that the moon had a certain rigidity for quite some time and could support this irregular feature from a time in its early history. This could be due to the probability that in its accumulation the moon acquired a variation, with angle, in the concentration of high-density material. If this occurred the highest density material would be located in the polar regions of the moon and the lowest density material located in the direction of the earth-moon radius vector. The geological aspects of the moon are not discussed in this paper. I.v.L.

N63-21620 Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena

TOPOLOGY OF THE LUNAR SURFACE

Zdenek Kopal (Manchester U., Gt. Brit.) *In* Va. Polytech. Inst. Proc. of the Conf. on Lunar Exploration, Aug. 12-17, 1962 p V-1 (Abstract) (See N63-21615 22-29)

The possible lunar internal processes, the structure of the lunar interior, and the influence of these two factors on the shape and topology of the lunar surface are discussed. Most of the evidence presented points to a viscoelastic model for the lunar interior. (It is the physical state of this interior which determines the shape and topology of the moon.) Also discussed are the determination of topographical features, the accuracy of their measurements, and methods for obtaining them. The influence of factors such as shape, optics, and position—as related the the accuracy of photographic interpretation—is presented. A description is given of the work currently being carried out by various groups to produce lunar charts. I.v.L.

N63-21621 Boeing Scientific Research Labs., Seattle, Wash. Geo-astrophysics Lab.

MEASUREMENTS OF LUNAR TEMPERATURE VARIATIONS DURING AN ECLIPSE AND THROUGHOUT A LUNATION

Richard W. Shorthill *In* Va. Polytech. Inst. Proc. of the Conf. on Lunar Exploration, Aug. 12-17, 1962 p VI/1-VI/63 25 refs (See N63-21615 22-29)

This report discusses: (1) infrared measurements during a lunation and during an eclipse; (2) radiothermal emission during lunation and during an eclipse. Also, isothermal maps are presented of: Tycho, Theophilus, Alphonsus, Dionysius, Proclus, Menelaus, Cleomedes, Posidonius, Copernicus, Kepler, and Aristarchus. The scanning for these isothermal maps took place on September 4, 5, 6, 1960. I.v.L.

N63-21622 Oliver Machinery Co., Grand Rapids, Mich.

THE NATURE OF THE LUNAR SURFACE AND MAJOR STRUCTURAL FEATURES

Ralph B. Baldwin *In* Va. Polytech. Inst. Proc. of the Conf. on Lunar Exploration, Aug. 12-17, 1962 p VII/1-VII/38 35 refs (See N63-21615 22-29)

In the early phase of the moon's history, the surface layers were hard and fairly thick. Craters of class 1 could be formed any time in this period. After they were formed, later impacts occurred which allow the dating of crater age on a relative scale based on the number of craters superimposed. In this period, the older the crater, the more it had been distorted by isotatic adjustment. In the terminal phases of the building of

the moon, the moon had developed a hard crust, but the interior was hot enough to weaken regions of the moon corresponding to the mantle of the earth. Isotatic adjustment then occurred on the surface. The amount of isotatic adjustment observed was greater in the largest craters and least in the smallest craters. After the maria developed, the local isotatic adjustment ceased, and the later craters, few in number, remained in class 1. The moon became more rigid after the development of the maria. Eventually, the moon beame tidally distorted due to its ability to adjust its form to exterior influences and due to the fact that the moon was close to the earth. It appears that the interior of the moon is now very hot, but not as hot as in earlier times, and that the outer layers have a finite strength sufficient to maintain a small bulge and to preserve craters for billions of years when similar objects on the earth would vanish quickly. I v L

N63-21643 Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena

ASTRONAUTICS INFORMATION. RECOMMENDATIONS FOR UTILIZATION OF LUNAR RESOURCES. SEMINAR PROCEEDINGS: A REPORT OF THE WORKING GROUP ON EXTRATERRESTRIAL RESOURCES, MARCH 8, 1963

George W. S. Johnson, ed. June 28, 1963. 70 p. 58 refs. (NASA Grant NAS7-100)

(NASA CR-51008) OTS: $6.60 ph, $2.30 mf

The feasibility and usefulness of the employment of extraterrestrial resources with the objective of reducing dependence of lunar and planetary exploration on terrestrial supplies is discussed with respect to the following: (1) lunar resources, (2) chemistry and physics of lunar surface, (3) power sources, (4) base construction and surface transporation, and (5) mining and processing. P v E

N63-21733 Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena

THE BEARING CAPACITY OF SIMULATED LUNAR SURFACES IN VACUUM

E. C. Bernett, R. F. Scott, L. D. Jaffe, E. P. Frink, and H. E. Martens. Aug. 15, 1963. 16 p. 7 refs.

(NASA Contract NAS7-100)

(NASA CR-51318, JPL-TR-32-326) OTS: $1.60 ph, $0.80 mf

The static bearing capacity of a granular material consisting of dry, crushed olivine basalt was determined in air and in a 10^{-6} mm Hg vacuum by means of cylindrical probes with a range of diameters. Samples with various particle size distributions (all below 35 mesh) were used for these tests. It was found that the packing density of these granular materials was the factor which had the greatest effect on the bearing capacity. The minimum bearing capacity of a loosely packed sample with a density of 1.25 g/cm^3 was about 0.1 kg/cm^2. The maximum bearing capacity of a densely packed sample with density of 2.1 g/cm^3 was about 7 kg/cm^2. The effects of vacuum were insignificant compared with the effect of packing density. Direct shear tests indicated the cohesion in a few densely packed samples to be 1.2×10^4 dynes/cm^2. For the small probes used, the cohesion was estimated to contribute 85% to 95% of the observed bearing capacity for the densely packed samples, but much less for the loosely packed samples. Author

N63-22374 National Aeronautics and Space Administration, Ames Research Center, Moffett Field, Calif.

ON THE LUNAR ORIGIN OF TEKTITES

D. R. Chapman and Howard K. Larson. Repr. from J. Geophys. Res., v. 68, no. 14, July 15, 1963, p. 4305-4358. 98 refs. Paper presented at 13th Intern. Astronautical Cong., Varna, (Bulgaria) Sept. 23-29, 1962

The experimental facilities and analytical methods of atmosphere entry aerodynamics have been applied to the study of tektites. Hypervelocity ablation experiments in the laboratory have reproduced the same surface sculptures, geometric relationships, systematic striae distortions, and coiled circumferential flanges as those found on tektites from Australia. The aerodynamic evidence demonstrates that the javanites and australites were twice melted, the second time by aerodynamic heating of rigid tektite glass during atmosphere entry. Experiments conducted on molten glass, ejected into the atmosphere at various viscosities, show that the primary australites were formed in an environment in which the atmosphere density was many orders of magnitude less than that at the earth's surface; this contradicts the hypothesis of tektite origin from the earth or other atmosphere-shrouded planets. Modern calculation methods for aerodynamic ablation are shown to be in good agreement with various laboratory experiments and with an entry flight experiment. From the amount of ablation, the distortion of striae, and the spacing between ring waves on australites, entry trajectories have been determined. The moon is the only known celestial body of origin compatible with these trajectories. The distribution of chemical elements in tektites, earth crust, meteorites, and other cosmic bodies is compared, and a brief discussion is given of the chemical differentiation of the lunar crust to which the overall evidence points. Author

N63-22841 American Astronautical Society, New York, N Y

MANNED LUNAR FLIGHT. ADVANCES IN THE ASTRONAUTICAL SCIENCES, VOLUME 10

George W. Morgenthaler and Horace Jacobs, eds. North Hollywood, Western Periodicals Co., 1963. 308 p. 166 refs. Proceedings of Am. Astronautical Soc. Symp. on Manned Lunar Flight, Denver, Dec. 29, 1961

(Co-Sponsored by NASA and the Am. Physiol. Soc.)

CONTENTS

15 LUNAR BASING J De Nike p 265-278
16 LUNAR EXPLORATION VEHICLES AND EQUIPMENT J Froehlich and A Hazard p 279 302 9 refs

N63-23311 Air Force Cambridge Research Labs., Bedford, Mass
A STATISTICAL APPROACH TO LUNAR GEOMETRY
Donald H Eckhardt (Arizona U.) and Mahlon S Hunt *In its* Compendium of Papers in the Fields of Geodesy and Planetary Geometry Aug 1963 23 p refs Presented at IAU Symp No 14 on the Moon, Leningrad, Dec 1960, and revised in Dec 1962 (See N63-23301 24-01)

Selenographers have been compiling maps of the moon for many years However, their inputs have relied substantially on parameters gained from applications of the physical theory of the moon and straightforward geometry Recently, through selenodetic photogrammetry, approaches utilizing statistical least squares theory have been introduced as possible approaches to the problem This paper defines one statistical approach through an application of the method of maximum likelihood, and makes a simple pilot error analysis Author

N63-23341 Douglas Aircraft Co., Santa Monica, Calif Missile and Space Systems Div
LUNAR MISCELLANY
J A Ryan Apr 1963 40 p refs
(SM-43544)

Lunar temperatures and their implications as to the nature of the lunar surface and lunar surface radioactivity are reviewed The maximum lunar surface temperature appears to be 400 K though there is some uncertainty as to this This maximum temperature occurs roughly at lunar noon and probably at or near the lunar equator During the lunar night the surface temperature drops to a low value, possibly in the neighborhood of 120 K but quite conceivably somewhat higher or significantly lower than this The rapid surface temperature changes with insolation changes indicate strongly, but do not prove that the surface material has a very low conductivity The best candidate for explaining this low conductivity appears to be a fine grained granular material An unshielded man at the lunar surface would probably receive a gamma dose of less than 6 rad for an exposure of one year Also grain soil density and engineering behavior parameters of lunar soil are discussed It is indicated that, for a given mass, the ultimate load bearing capacity of lunar soil is independent of the gravitational force, however, for a given load, the lunar soil has a smaller bearing capacity (smaller by a factor of six) than the terrestrial soil I v L

N63-23402 Douglas Aircraft Co., Santa Monica, Calif Missile and Space Systems Div
CORPUSCULAR RADIATION PRODUCED CRYSTALLINE DAMAGE AT THE LUNAR SURFACE
J A Ryan May 1963 46 p refs Presented to the Lunar Surface Materials Conf., Boston, May 22, 1963 Submitted for Publication
(Engineering Paper No 1632)

The corpuscular radiation flux incident upon the lunar surface, the dissipation of the energy contained in this flux with depth below the surface, and the effects of this upon the crystalline structure of the lunar material are considered The major contributors to the corpuscular radiation flux at the lunar surface are the solar and galactic particles Assuming that a static condition exists at the lunar surface, the following conclusions are presented (1) no significant radiation produced crystalline damage has occurred below a depth of about 2 g cm $^{-2}$ (2) in the depth range 1 to 2 g cm $^{-2}$, significant damage could occur, but it appears that this could not be great enough to completely disrupt the crystalline structure (3) in the depth range 0 to 1 g cm $^{-2}$, it is possible that metamictization could occur R T K

N63-23454 California U., Berkeley
LIFE BEYOND THE EARTH
Carl Sagan *In* USIA Voice of Amer Forum Ser on Space Sci., Jan 8-May 21 1962 p 297-310 (See N63-23436 24-01)
(Lecture 20)

The interrelated questions of extraterrestrial life and the origin of life on Earth are considered A theory of the origin of life in the primitive oceans is reviewed, and the laboratory recreation of life is regarded as a likely possibility The primitive environments of the other planets are expected to have been similar to the primitive environment of the Earth Information on the present atmospheric and surface conditions of Venus, Mars, the Moon, and the Jovian planets is reviewed and related to the possibility of existence of life based on organic matter The existence of life based on some other kind of chemistry is beyond comprehension at present Speculation on extraterrestrial life has been popular over the years, but the prospect of actual experimentation to solve this question belongs to this generation The importance of sterilizing the interiors of all space probes in order to prevent contamination of extraterrestrial areas with terrestrial microorganisms is stressed M P G

N63-23735 Air Force Systems Command, Wright-Patterson AFB, Ohio Foreign Tech Div
ONE MORE PORTRAIT OF THE MOON
L Strizhevskaya May 10, 1963 7 p Transl into ENGLISH from Izvestiya, Sept 9, 1962 p 3
(FTD-TT-63-335/1)

An infrared system for taking pictures of the moon is discussed The photographs are taken in infrared rays in the range 0.9 to 2.3 microns, but not directly on a photographic plate Instead, an intermediate converter (a television apparatus) for converting the invisible red rays into visible rays is used The image of the moon, amplified with the aid of a telescope, is directed onto a television pickup which is sensitive to infrared rays P V E

1964

N64-10097 Texaco Experiment Inc., Richmond, Va.
SURVEYOR GEOPHYSICAL INSTRUMENT, VOLUME I: SURFACE GEOPHYSICAL INSTRUMENT—PROTOTYPE NO. I
Interim Report
R. E. Canup, R. H. Clinard, Jr., V. M. Barnes, Jr., J. R. Bond, R. P. Doelling et al May 1, 1962 229 p refs
(Contract JPL-95015)
(NASA CR-52133; TP-192; EXP 387) OTS: $15.00 ph, $7.07 mf

The instruments included are designed to measure temperature, thermal diffusivity, magnetic susceptibility, density, penetrability, and acoustic velocity of the lunar surface. For each instrument, a system and equipment description, report of testing and calibration, components outline, description of packaging philosophy, theoretical studies, and environmental test results, and a recommendations section are included Author

N64-10179 Aerojet-General Corp., Azusa, Calif. Chemical Products Div.

RESEARCH ON PROCESSES FOR UTILIZATION OF LUNAR RESOURCES Quarterly Report [22 Apr.-31 July 1963]

S. D. Rosenberg, G. A. Guter, and F. E. Miller Aug. 1963 29 p (NASA Contract NAS7-225)

(NASA CR-52318, Rept. 0765-01-1) OTS: $2.60 ph, $1.07 mf

Laboratory apparatus for studying the catalytic reduction of carbon monoxide with hydrogen has been designed, fabricated, and operated. Excellent yields of methane (to 99.0%) and water (to 100%) were achieved; minor amounts of carbon dioxide were formed as a byproduct. A negligible amount of carbon (less than 0.1%) was deposited on the catalyst during several hours of operation. The reaction appears very promising as a step in the reduction of silicate materials (lunar new materials) to produce oxygen. Author

N64-10373 Arizona U., Tucson.

COMMUNICATIONS OF THE LUNAR AND PLANETARY LABORATORY. VOLUME 2, NUMBER 24-29

William K. Hartmann et al. 1963 113 p refs

(NASA Grant NsG-161-61)

(NASA CR-52400) OTS: $9.60 ph, $3.59 mf

The system of radial structures in the uplands surrounding Mare Imbrium contains a variety of objects and has modified certain pre-mare features. Many of the structures cannot be the result of gouging by flying fragments. They may have formed along radial fractures associated with an Imbrium impact. The morphological evidence for crustal breakup suggests that this impact occurred during a high-temperature stage in the outer layers of the moon when the surface was in tension and the subsurface plastic. Author

N64-10374 Arizona U., Tucson

COMMUNICATIONS OF THE LUNAR AND PLANETARY LABORATORY. VOLUME 2, NUMBER 30 [THE SYSTEM OF LUNAR CRATERS, QUADRANT I]

S. W. G. Arthur et al. 1963 84 p refs

(NASA Grant NsG-161-61)

(NASA CR-52401) OTS: $8.10 ph, $2.72 mf

The designation, diameter, position, central peak information, and state of completeness for each discernible crater in the first lunar quadrant with a diameter exceeding 3.5 km are listed. The catalog contains about 2,000 items and is illustrated by a map in 11 sections. Author

N64-10625 General Mills, Inc., Minneapolis, Minn. Electronics Div.

INVESTIGATION OF SPUTTERING EFFECTS ON THE MOON'S SURFACE

G. K. Wehner, D. L. Rosenberg, and C. E. KenKnight Nov. 12, 1963 30 p refs

(NASA Contract NASw-751)

(NASA CR-52534) OTS: $2.60 ph, $1.10 mf

Experiments to investigate the influence of sputtering of the lunar surface by the solar wind were continued. Enrichment of metal concentration in surface layers of metallic oxides under hydrogen and mercury bombardment was demonstrated by X-ray scattering from the powders. An optical device for measurements of powder reflectivities is described and employed to measure the reflectivity of various materials. Powder surfaces sputtered under normal ion incidence are changed toward better agreement with the lunar results. Most surfaces are simultaneously darkened, in agreement with the low lunar albedo. Crusts of copper oxides after sputtering had high electrical conductivity. Buildup of copper oxide crusts from falling powder during sputtering resulted in cementing not otherwise observed. Sputtering of Fe, Ni, and Au wires by mass analyzed beams of hydrogen molecular ions support the theoretically expected sec θ dependence upon angle of incidence for 2 to 4 kev protons. Author

N64-10860 National Aeronautics and Space Administration, Washington, D. C.

EXPERIMENTS FOR THE UNMANNED SCIENTIFIC EXPLORATION OF THE MOON

Newton W. Cunningham. Repr. from Lunar and Planetary Programs, p. 526-530

The unmanned exploration of the moon is expected to provide answers to a great many questions concerning the history of the earth-moon system and the origin of other bodies in our solar system. The means for obtaining these answers lie in the efficient use of a variety of scientifically instrumented spacecraft capable of probing, measuring, analyzing, and observing the properties of the lunar environment, surface, and subsurface. Some of the experiments being considered for lunar rough- and soft-landing payloads are discussed, as well as the type of information that would be most desirable from a lunar orbiter. A brief résumé of the steps necessary in the development of instrumentation for unmanned geologic investigations is also presented. Author

N64-10929 Massachusetts Inst. of Tech., Cambridge

RADIOMETRIC MEASUREMENTS IN RADIO ASTRONOMY

Victor K. Chung. *In* RAND Corp. The Appl. of Passive Microwave Technol. to Satellite Meteorology. A Symp. Aug. 1963 p. 218-219 (See N64-10911 02-01) OTS: $17.00 ph, $8.15 mf

Plans for a program in radio astronomy, which will investigate the Earth's atmosphere and the extraterrestrial sources of radio emission, are summarized as follows. (1) A ground-based radiometer looking skyward at various angles with respect to the zenith will be used for studying the distribution and abundance of water vapor in the atmosphere. The radiometer will track the Sun and the Moon. (2) Radiometric measurements will be taken of several sources, primarily Venus, Jupiter, and some of the other stronger sources. (3) An attempt will be made to take spectra of gases at very high pressures. (4) Measurements of the emissive properties of some common materials will be made at frequencies planned for the radiometers. (5) An attempt will be made to transistorize all equipment so that it can be flown in a balloon and perhaps even in a satellite. I. v. L.

N64-11222 Joint Publications Research Service, Washington, D. C.

TELEVISION PHOTOGRAPHY OF THE MOON

N. F. Kuprevich 18 Jul. 1963 11 p refs Transl. into ENGLISH of an article from Priroda (Moscow), no. 4, 1963 p. 90-93

(JPRS-20223; OTS-63-31315) OTS: $0.50

Experiments on the use of infrared vidicons for photographing the moon are described. In photographing the image of the moon in the infrared region, using the television system, a series of transformations occurs. A block diagram of the television telescope with infrared vidicon is given. R. T. K.

N64-11294 New Mexico State U. University Park
CONTINUED PHOTOGRAPHIC PATROL AND STUDY OF THE PHYSICAL CONDITIONS ON THE MOON AND PLANETS Semi-Annual Report No. 5, 15 Apr.-14 Oct. 1963
Clyde W. Tombaugh [1963] 5 p
(NASA Grant NsG-142-61)
(NASA CR-52850) OTS: $1.10 ph, $0.80 mf

During most of this period, both Venus and Mars were unfavorably placed for effective observation. Saturn was quiescent as evidenced by scarcely any change of markings on the disk. On the other hand, Jupiter was extemely active with many rapid changes in the markings, which were well observed under the very favorable circumstances of a perihelion opposition occurring once in 12 Earth years. Author

N64-11393 Cornell U., Ithaca, N.Y. Center for Radiophysics and Space Research
PHOTOMETRIC STUDIES OF COMPLEX SURFACES, WITH APPLICATIONS TO THE MOON
Bruce Hapke and Hugh Van Horn Repr. from J. Geophys. Res. v. 68, no. 15, 1 Aug. 1963 p 4545-4570 refs
(NASA Grant NsG-119-61)

The reflection laws of a wide variety of surfaces have been measured. The factors that govern the optical scattering characteristics of complex surfaces are discussed, and the properties of surfaces that scatter light like the moon are specified. Surfaces of solid rocks, volcanic slags, or coarsely ground rock powders do not have the intricate structure necessary for backscattering light strongly but finely pulverized dielectric particles can build extremely complex surfaces that can reproduce the lunar scattering law. It is concluded that the surface of the moon is covered with a layer of fine rock dust composed of particles of the order of 10-micron average diameter, and that 90 percent of the volume of the surface layer is voids. Author

N64-11906 National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, Md.
DUST BOMBARDMENT ON THE LUNAR SURFACE
Curtis W. Mc Cracken and Maurice Dubin (NASA, Wash.) Washington, NASA, Dec. 1963 25 p refs Presented at the Lunar Surface Mater. Conf., Boston, 21-23 May 1963 Submitted for Publication
(NASA TN D-2100) OTS: $0.75

A porous, low-density surface layer, consistent with photometric and radiometric observations, is assumed to exist on the moon, and the effects of the impacting dust particles are considered. The interplanetary particulate material accreted by the moon amounts to approximately 1 gm/cm^2 for dust particles with masses less than 10^4 gm if the flux has remained constant during the past 4.5×10^9 yr. This value for the accretion rate represents a lower limit if the flux has decreased appreciably since the time of formation of the major lunar surface features. The porous surface layer acts as a protective covering against hypervelocity impacts of small dust particles, and inhibits the production of high-speed spray particles which could escape from the moon. The surface layer therefore consists of a mixture of lunar and interplanetary material. The hypervelocity impacts of dust particles constitute an effective mechanism for development and maintenance of a dendroid surface layer of high porosity and low density. Author

N64-12018 Boeing Scientific Research Labs., Seattle, Wash. Geo-Astrophysics Lab.
INFRARED MAPPING OF LUNAR CRATERS DURING THE FULL MOON AND THE TOTAL ECLIPSE OF SEPTEMBER 5, 1960
J. M. Saari and R. W. Shorthill Jul. 1963 83 p refs
(Contract AF 18(600)-1824)
(DI-82-0176)

Infrared measurements were made over certain lunar crater regions during the eclipse of September 5, 1960, and the full moon. Five rayed craters were observed to cool less rapidly than their environs during the eclipse, the anomaly being greatest for Tycho and progressively less for Aristarchus, Copernicus, Proclus, and Kepler. The findings are discussed in terms of the thermal properties of the surface, including thickness of insulating layer and age of the craters. Localized variations were found during illumination, evidently attributable to variations in albedo and geometry. Author

N64-12351 Space Technology Labs., Inc., Redondo Beach, Calif.
INSTRUMENTATION FOR A MINERALOGICAL SATELLITE
Eugene A. Burns and R. J. P. Lyon (Stanford Res. Inst.) [1963] 26 p refs Presented at the 14th Intern. Astronautical Congr., Paris, 25 Sep.-1 Oct. 1963
(Partially supported by NASA)
(IAC Paper 94; Rept. 9990-6459-RU-00)

The theoretical basis, operational considerations, instrumental constraints, feasibility, and application of a mineralogical satellite are discussed. From the discussion, it is concluded that the remote infrared spectral measurement of the lunar surface will provide valuable information for mineralogical and temperature mapping; it may also introduce a method to determine the general particulate structure. Instrumentation for such a satellite exists in state-of-the-art hardware and detection techniques. The extension of this concept to other planets is limited only by the atmospheric absorption of infrared energy P.V.E.

N64-12404 California U., Berkeley Space Sciences Lab.
POSSIBLE ORIGIN OF THE LUNAR WALLED PLAIN PTOLEMAEUS
R. G. Strom and A. Palm Repr. from Nature, v. 199, no. 4898, 14 Sep. 1963 p 1052-1054 refs
(NASA Grant NsG-145-61)

Ptolemaeus is one of several aligned large craters or walled plains located along the border of Mare Nubium. The tectonic relationships between the Ptolemaean ghost features and the Imbrium radial system suggest that the formation of Ptolemaeus may have been contemporaneous with that of Mare Imbrium and that its evolution possibly proceeded in the following stages: (1) subsidence of a segment of crust containing preexisting structures; (2) formation of craters and related features within the subsided area; (3) inundation of the existing structures by lava and dust; and (4) formation of post-lava craters. I.v.L.

N64-12678 Arnold Engineering Development Center, Arnold Air Force Station, Tenn.
ENGINEERING PROBLEMS IN A LUNAR ENVIRONMENT
Donald D. Carlson and George Mac Farlane July 1963 30 p refs
(AEDC-TDR-63-169; AD-422956)

The principal characteristics of the cislunar and lunar, environments are identified, and the influences that such environmental parameters have upon engineering designs applicable to lunar operations are outlined. Basic astronomical data and some illustrations of typical lunar topography are also included. Author

N64-12798 Joint Publications Research Service, Washington, D.C.
DUST NATURE OF THE LUNAR SURFACE AND DETERMINING FIGURE OF THE EARTH THROUGH GRAVITY ANOMALIES
N. S. Orlova et al 15 Jul. 1963 22 p refs Transl. into ENGLISH of 2 articles from Tr. Astron. Observ. (Leningrad), no. 307, 1962 p 179-186 and 234-242
(JPRS-20167; OTS-63-31282) OTS: $0.75

CONTENTS:
1. SLOPE ANGLES OF LOOSE MATERIALS AND HYPOTHESES OF THE DUST NATURE OF THE LUNAR SURFACE N. S. Orlova p 1-9 refs (See N64-12799 04-29)
2. DETERMINATION OF THE FIGURE OF THE EARTH THROUGH ANOMALIES OF THE VERTICAL GRADIENT OF GRAVITY S. V. Gromov p 10-19 ref (See N64-12800 04-12)

N64-12799 Joint Publications Research Service, Washington, D.C.
SLOPE ANGLES OF LOOSE MATERIALS AND HYPOTHESES OF THE DUST NATURE OF THE LUNAR SURFACE
N. S. Orlova *In its* Dust Nature of the Lunar Surface and Determining Figure of the Earth Through Gravity Anomalies 15 Jul. 1963 p 1-9 refs (See N64-12798 04-01) OTS: $0.75

Evidence is presented that dust or other loose cover cannot provide a surface whose unevenness would correspond to the photometric relief of the lunar surface. Laboratory experiments were performed to determine the angle of natural slope for various samples of loose materials (sand, dust, volcanic ash, etc.) heaped into a natural cone. Most of the materials gave slope angles of 25° to 30°; the greatest value, 45°, was obtained for powdered clay. Photographs of natural volcanoes were examined to determine the slope angles of the volcanic cones; most ranged from 30° to 35° and none exceeded 45°. Models with a pitted surface whose maximum angles of nonuniform slope were equal to 45° were examined at various angles of illumination; the resulting curves were not similar to those obtained photometrically for the lunar surface. The conclusion is drawn that, if the angles of natural slope of natural materials have the same value under lunar conditions as on earth, then enormous expanses covered by noncemented dry materials do not exist on the lunar surface. M.P.G.

N64-12876 National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, Ala.
TOUCHDOWN DYNAMICS ANALYSIS OF SPACECRAFT FOR SOFT LUNAR LANDING
Robert E. Lavender Washington, NASA, Jan. 1964 39 p refs (NASA TN D-2001) OTS: $1.00

Parameters used in the analysis include the local lunar slope, coefficient of friction, initial touchdown vertical and horizontal velocity components, vehicle weight and radius of gyration, height of the center of gravity, displacement of the center of gravity from the vehicle's longitudinal axis, thrust of stabilization rocket motors, crushing force of energy absorbing material in the leg struts, and number of legs. Results show that the lunar slope, which was varied up to 40 degrees, and the coefficient of friction have a large effect on the landing gear diameter required for touchdown stability. The initial touchdown vertical and horizontal velocity components also have a large influence on the required landing gear diameter. Variations in the height of the center of gravity, displacement of the center of gravity from the vehicle's longitudinal axis, vehicle weight and radius of gyration, and crushing force of the energy absorbing material have less influence on the landing gear design. The use of a stabilization rocket motor is highly effective in providing adequate touchdown dynamic stability. With a properly chosen scheme for providing motor ignition, tumbling of the vehicle under severe conditions of lunar slope and friction can be prevented with a motor of relatively low total impulse. Author

N64-13136 Bellcomm, Inc., Washington, D.C.
LUNAR LOGISTIC SYSTEM SCIENTIFIC FACILITY
C. A. Pearse and H. W. Radin 31 Jan. 1963 16 p refs

The major objective of this study is to examine possible methods for increasing the overall scientific capability of early Project Apollo missions, utilizing a nominal 1500-pound payload delivered by a C1-B, automated LEM, or C-5 Lunar Logistic Vehicle. Of the several alternatives considered, the establishment of a lunar surface laboratory is found to be the most effective means of enhancing the early scientific capability. Some major advantages of a lunar surface laboratory are cited, and a balanced group of pertinent experiments is proposed. These experiments are separated into two broad categories: experiments to obtain specific information about the moon, and experiments which use the moon as a stable space platform from which to make astrophysical observations. Author

N64-13334 Boston U., Mass.
LUNAR CRATER STATISTICS: THE HIGHLAND REGIONS Research Report No. 7, Aug. 1963
David Friesen Aug. 1963 31 p refs
(NASA Grant NsG-246-62)
(NASA CR-55172; *Its* Chem. Contrib. Ser. II, No. 25) OTS: $3.60 ph, $1.13 mf

The crater diameter (D) vs cumulative frequency of occurrence (N) for lunar craters can be described by equations of the form $N = AD^B$ with the constants A,B empirically determined from actual counts of craters. It is found, however, that a single set of constants does not adequately describe the cumulative distribution function. Two sets of constants are required, their average value for a normalized area (10^6 km) being:

(1) D >40 km, A = 30,350, B = −2.392;
(2) D <40 km, A = 9.035, B = −1.263.

Author

N64-13407 Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
SPACE PROGRAMS SUMMARY NO. 37-16, VOLUME VI FOR THE PERIOD MAY 1, 1962-AUGUST 1, 1962. SPACE EXPLORATION PROGRAMS AND SPACE SCIENCES
31 Aug. 1962 79 p refs
(NASA Contract NAS7-100)
(NASA CR-53036; JPL-SPS-37-16, Vol. 6) OTS: $7.60 ph, $2.57 mf

Activities in the following areas are summarized: (1) the lunar program—Ranger project and Surveyor project; (2) the planetary-interplanetary program—Mariner project and Voyager project; (3) the Deep Space Instrumentation Facility (DSIF); and (4) space sciences—lunar studies, planetary studies, and solar and interplanetary studies. P.V.E.

N64-13702 National Aeronautics and Space Administration, Washington, D.C.
THE MANNED LUNAR BASE
G. A. Smith *In* North American Aviation, Inc. Proc. of the [13th] Lunar and Planetary Exploration Colloq. Vol. 3, No. 3 Nov. 1963 p 3-9 (See N64-13701 05-01)

Our nation's current and future space missions may be classified as those planned for orbit and for the regions of the moon and planets. Of primary importance is the establishment of a manned lunar base for scientific exploration of the moon and exploitation of the lunar environment. A lunar station, whether an Apollo stay-time extension, or a permanent or semipermanent base, could also provide essential data and support for future, more complex planetary expeditions. Studies have been conducted to determine the life-support requirements and special facilities, including transportation, communication, and power necessary to maintain such a base. A review is made of the current thinking among qualified scientists regarding man's role in lunar and planetary exploration. It is generally concluded that the immediate training of scientist-astronauts is necessary to achieve and maintain pre-eminence in space. Author

N64-13704 Space Technology Labs., Inc., Los Angeles, Calif.

THE LUNAR ATMOSPHERE AND ITS RELATIONSHIP TO THE SOLAR WIND

W. Bernstein, R. W. Fredricks, and J. L. Vogl *In* North American Aviation, Inc. Proc. of the [13th] Lunar and Planetary Exploration Colloq., Vol. 3, No. 3, Nov. 1963 p 15–21 refs (See N64-13701 05-01)

Several possible lunar model atmospheres and ionospheres are computed; the gases considered are hydrogen, nitrogen, neon, argon, krypton, and xenon. The contributions from the lunar surface and the solar wind are discussed. Various atmospheric loss processes as a result of the solar wind interaction, including scattering, electrostatic acceleration, and magnetic field attachment, are included. The reasonable model atmospheres are in agreement with estimates of the density derived from radio-astronomy measurements. Author

N64-13705 Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena

THE PHYSICAL NATURE OF LUNAR SURFACE MATERIAL

Albert R. Hibbs *In* North American Aviation, Inc. Proc. of the [13th] Lunar and Planetary Exploration Colloq., Vol. 3, No. 3, Nov. 1963 p 23–28 refs (See N64-13701 05-01)

The fraction of lunar material which has not been subject to melting and that fraction which has been subject to vaporization and redeposition as a result of impacts (even if originally solidified from a melt) should be deposited on the surface of the moon in the form of whisker crystals or needles. This result was indicated by laboratory experiments on the condensation of material from a vapor to a solid phase in a region of pressure and temperature that precludes a liquid phase and that would apply to material condensing from the vapor to a solid phase on the surface of the moon or, generally, in interplanetary space. Author

N64-13706 Lockheed-California Co., Burbank

THE SHAPE OF THE MOON: A SPECIAL REPORT

L. Larmore *In* North American Aviation, Inc. Proc. of the [13th] Lunar and Planetary Exploration Colloq., Vol. 3, No. 3 Nov. 1963 p 29–30 (See N64-13701 05-01)

To determine the shape of the moon, two annular eclipses were photographed. The first occurred July 31, 1962. Seventeen photographs were taken from a site about 100 miles east of Dakar in northern Africa. The second occurred January 25, 1963. It was photographed fully from a site about 600 miles from Johannesburg in southern Africa. Equipment included a heliostat and a 55-ft focal length mirror. Author

N64-13707 North American Aviation, Inc., Downey Calif. Space and Information Systems Div.

CONCEPTS OF BASE CONSTRUCTION ON THE MOON

George W. S. Johnson *In its* Proc. of the [13th] Lunar and Planetary Exploration Colloq., Vol. 3, No. 3 Nov. 1963 p 31–37 refs (See N64-13701 05-01)

A lunar base will be used for exploration, and for equipment development and testing. It will be the forerunner of future bases on the planets, or their satellites. As such, it should develop techniques for living-off-the-land, thus reducing logistical supplies from earth. Examining the functions indicates that the base must be dispersed over an area of several miles, thus requiring a manned surface vehicle. A power, or energy source, may be the pacing item in base utilization. Ore-processing equipment for obtaining water, and subsequently hydrogen and oxygen by electrolysis, is probably of next importance. However, more knowledge about the lunar surface is urgently needed to make meaningful design studies of lunar bases. Author

N64-13708 Little (Arthur D.) Inc., Cambridge, Mass

THE IMPLICATIONS OF WATER AS A LUNAR RESOURCE

Peter E. Glaser, Alfred E. Wechsler, and John W. Salisbury (AFCRL) *In* North American Aviation, Inc. Proc. of the [13th] Lunar and Planetary Exploration Colloq., Vol. 3, No. 3 Nov. 1963 p 39–53 refs (See N64-13701 05-01)

Lunar water deposits, when economically exploited, can play an important role in the logistics of space exploration. Evidence is given to support the existence of surface and subsurface water deposits. The physical properties of possible water deposits are discussed, and their influence on possible recovery methods is indicated. Energy sources and water extraction processes are categorized as: (1) in situ processes with direct application of heat; (2) in situ processes requiring remote power sources; (3) in situ processes requiring no primary energy sources; and (4) processes using mined deposits. The utilization of nuclear and solar energy for these processes is considered. Author

N64-13709 Texas Instruments, Inc., Dallas

EXPLORATION FOR LUNAR WATER DEPOSITS

J. R. Van Lopik and K. Westhusing *In* North American Aviation, Inc. Proc. of the [13th] Lunar and Planetary Exploration Colloq., Vol. 3, No. 3 Nov. 1963 p 55–63 refs (See N64-13701 05-01)

The locating of lunar water deposits is critical to any extensive, lunar-based program of scientific investigation in space. Exploration for water on the moon will use tools of terrestrial exploration, both contact and noncontact techniques, which will generate "converging" data to delineate deposits. Techniques which hold particular promise for work in either lunar meteorite or volcanic terrains are: multiband remote-sensing techniques (e.g., visual, infrared, and radar), and the on-surface geophysical methods, such as electrical resistivity, nuclear activation, gravity-magnetic traversing, and seismic profiling. Author

N64-13710 Douglas Aircraft Co., Inc., Santa Monica, Calif.

SOME ASPECTS OF LUNAR SOIL BEHAVIOR

J. A. Ryan *In* North American Aviation, Inc. Proc. of the [13th] Lunar and Planetary Exploration Colloq., Vol. 3, No. 3 Nov. 1963 p 65–71 refs (See N64-13701 05-01)

The possible effects of vacuum upon soil behavior are discussed. Emphasis is given to the role the lunar soil may play in a lunar basing operation. It is concluded that the lunar soil may behave in a manner unlike that of any terrestrial soil.

Hence, caution must be exercised in the choice of the terrestrial soil-mechanics equations which may adequately describe this soil's behavior. In addition, it is concluded that possible adhesion between the soil and engineering materials poses a serious problem to any lunar basing operation. Author

N64-13712 North American Aviation, Inc., Downey, Calif. Space and Information Systems Div.
SOME LUNAR RESOURCES
Jack Green *In its* Proc. of the [13th] Lunar and Planetary Exploration Colloq., Vol. 3, No. 3 Nov. 1963 p 83-95 refs (See N64-13701 05-01)

Volcanic terrains offer more survival advantages in lunar basing than impacted terrains. Therefore, calderas should be sought on the moon regardless of whether they occupy 1 percent or over 95 percent of the lunar surface. Such volcanic areas would contain easily worked materials, such as nonwelded tuffs or lava tubes, for housing or protection. Rock types suitable for casting purposes may be found on the lunar maria. Volcanic rocks would be variably hydrous but, on the average, wetter than meteorite rocks. Epithermal logging techniques would be valuable in locating hydrous deposits, especially in topographically low portions of volcanic basins. Mineralization in quantities realistic for lunar basing purposes is found in volcanic terrains and includes sulfur, alunite, pyrite, and other hydrothermal products. Subsurface heat useful in lunar basing would be likely in certain lunar calderas, volcanoes, or in recent fracture zones that ray patterns may represent.
Author

N64-13928 Boston U., Mass.
INTERSECTIONS OF LUNAR CRATERS Research Report No. 6
David Friesen Sep. 1963 12 p refs
(NASA Grant NsG-246-62)
(NASA CR-55274) OTS: $1.60 ph, $0.80 mf

An examination was made of the intersection frequency of lunar craters by other craters for both large and small craters in the highland region. A theoretically expected frequency was calculated and compared with the actual frequency measured from the Boston University Catalog of Lunar Craters. A close agreement was found between the calculated intersection frequency and the actual frequency. R.T.K.

N64-14276 Boston U., Mass.
CATALOG OF LUNAR CRATERS III Research Report No. 8
Gerald S. Hawkins and Peter W. Mitchell Nov. 1963 26 p refs
(NASA Grant NsG-246-62)
(NASA CR-55295 *Its* Astronomical Contributions, Ser. 2, no. 26) OTS: $2.60 ph, $0.98 mf

The selenographic coordinates of all craters observable on a selected portion of the moon's surface are given, together with the diameter of the craters and comments on their shape. The section studied was a strip on sheet C 7-a of the Photographic Lunar Atlas. (Kuiper, 1960) The position found in the present series of measurements is given, along with the name adopted by the International Astronomical Union.
C.L.W.

N64-14281 Boston U., Mass.
REVISED CATALOG OF LUNAR CRATERS II Research Report No. 11
Gerald S. Hawkins and Peter W. Mitchell Nov. 1963 25 p refs
(NASA Grant NsG-246-62)
(NASA CR-55297 *Its* Astron. Contrib., Ser. 2, no. 28) OTS: $2.60 ph, $0.95 mf

This catalog gives the selenographic coordinates of all craters observable on a selected portion of the moon's surface. The diameter of the crater, together with comments on the shape, is also given. Approximately 15 percent of the craters have been measured previously by other observers. The craters positions found in the present series of measurements and the name adopted by the International Astronomical Union are presented. R.T.K.

N64-14282 Boston U., Mass.
REVISED CATALOG OF LUNAR CRATERS I Research Report No. 10, November 1963
Gerald S. Hawkins and Peter W. Mitchell [1963] 25 p refs
(NASA Grant NsG-246-62)
(NASA CR-55296) OTS: $2.60 ph, $0.95 mf

This catalog gives the selenographic coordinates of all craters observable on a selected portion of the moon's surface. The portion studied was a strip on sheet C 5-a of the "Photographic Lunar Atlas" (Kuiper, 1960). The diameters of the craters and comments concerning their shape are given. The position of the geometrical center of the crater rim is also given. If the rim is raised above the mean level of the moon, then the measured center is displaced toward the limb of the moon. This displacement, in general, is less than 1 km and is negligible compared to the uncertainty of defining the rim for a large crater. I.v.L.

N64-14359 New Mexico State U., University Park
PLANETARY AND LUNAR RESEARCH IN THE PHOTOGRAPHIC INFRARED, VISIBLE AND ULTRAVIOLET Semi-Annual Report No. 5, 1 Apr.-30 Sep. 1963
Clyde W. Tombaugh Oct. 1963 5 p
(Grant DA-ARO(D)-31-124-G41) OTS: $1.10
(AD-428392)

Activities dealing with the observation of Venus, Mars, Jupiter, and Saturn are discussed. P.V.E.

N64-14841 California U., Berkeley Space Sciences Lab.
ON OBSERVATIONS OF LUNAR MAGNETIC STORMS
A. Palm and S. Silver 9 Jan. 1964 5 p refs
(NASA Grant NsG-243-62)
(NASA CR-55433, *Its* Ser. 5, Issue 3) OTS: $1.10 ph, $0.80 mf

Consideration is given to a plan for obtaining information on geomagnetic phenomena through the stationing of plasma detectors on the moon. Several types of magnetic disturbances are described in order to demonstrate possible differences between selenomagnetic and geomagnetic storms caused by identical solar events. Primary factors are separated from secondary effects due to the earth's environment by correlating recordings of terrestrial magnetic fluctuations and of lunar plasma probes and magnetometers. A single base stationed on the moon for this purpose provides the longest period of time during which a given solar event and its developments can be examined continuously and simultaneously by optical, radiometric and magnetometric methods. C.L.W.

N64-15175 General Mills, Inc., Minneapolis, Minn. Electronics Div.
MODIFICATION OF THE LUNAR SURFACE BY THE SOLAR-WIND BOMBARDMENT
G. K. Wehner, C. E. Kenknight, and D. Rosenberg Repr. from Planet. Space Sci., v. 11 1963 p. 1257-1261 refs
(NASA Contract NASw-424)

Long-duration, solar-wind sputtering conditions were simulated at a much accelerated scale with mass-separated hydrogen ion beams or in low-pressure, noble gas or hydrogen plasmas. Experiments with metal targets and metal-, oxide-, and rock-powder samples demonstrate the leveling and smoothing of macroscopic surface features and cementing together of loose particles into a porous, brittle, fibrous crust. Certain oxide surfaces become enriched with metal atoms under the bombardment and sputtering action. It is concluded that many of the unusual properties of the lunar surface can be explained by the action of solar-wind bombardment. Author

N64-15183 California U., Los Angeles. Inst. of Geophysics and Planetary Physics.
THE INTERNAL CONSTITUTIONS OF THE INNER PLANETS AND THE MOON
Gordon J. F. Mac Donald. *In its* Notes for the Summer Inst. in Planetary Phys., 1963, 155 p. refs. (See N64-15182 07-01) OTS: $21.00 ph, $11.03 mf

The internal structures of the Moon, Mars, Venus, and Mercury are examined in the light of what is known about the constitution of the Earth. The gravitational figure of the Earth, as obtained from orbits of artificial satellites, is used to estimate the possible deviations from hydrostatic equilibrium on other planets. Observations of the orbital and rotational motion of the Moon are consistent with the hypothesis that the interior of the Moon supports density inhomogeneities of the same order as those supported by the Earth. The surface heat flow for the Earth is consistent with the hypothesis that the concentration of radioactive elements is the same as that in chondritic meteorites. The observed ratio of potassium to uranium in surface and near-surface rocks is not consistent with the chondritic hypothesis. It is concluded that a chondritic composition is not a satisfactory chemical model for the inner planets. R.T.K.

N64-15186 Ohio State U. Research Foundation, Columbus. Antenna Lab.
THEORETICAL AND EXPERIMENTAL ANALYSIS OF THE ELECTROMAGNETIC SCATTERING AND RADIATIVE PROPERTIES OF TERRAIN, WITH EMPHASIS ON LUNAR-LIKE SURFACES. Semi-Annual Report, 1 May-31 Oct. 1963
1 Nov. 1963, 26 p. refs.
(NASA Grant NsG-213-61)
(NASA CR-55545, Rept. 1388-12) OTS: $2.60 ph, $0.98 mf

Relations between the electromagnetic scattering properties of a surface (in particular the lunar surface) and its surface structure were examined. Measurements of the complete bistatic scattering pattern of a number of rough surfaces were carried out at X-band. Theoretical studies have been made of the polarization transformation properties of rough surfaces, and these have been used to interpret lunar scattering measurements made with linear polarization. Other studies of the lunar scattering problem have been concerned with the relation between spectrum and angular dependence (for CW scattering experiments) and with the correlation properties of the scattered signal (for two-frequency scattering experiments). Author

N64-15196 Minneapolis-Honeywell Regulator Co., Minn. Military Products Group.
PRECISION DETERMINATION OF THE POSITION OF THE CENTER OF THE MOON'S MASS FROM PHOTOGRAPHIC OBSERVATIONS
N. F. Bystrov. [1962] 13 p. refs. Transl. into ENGLISH of an article from Astron. Zh. (Moscow), v. 39, no. 3, p. 527-531 (MH Transl. 401)

Factors that influence the precision of the photographic determination of coordinates of the center of the moon's mass are investigated. The results of visual and photoelectric measurements of photographs of the moon are compared. A method is proposed for obtaining the position of the center of the moon's mass relative to details on the disk. Author

N64-15284 National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, Md.
TEKTITES AND THE MOON
John A. O'Keefe. *In* Georgetown U., Washington, D.C. Recent Advances in Astro-Geophysics [1961] p. 60-65 (See N64-15276 07-01)

A review of theories concerning the origins of tektites is presented. The conclusions that may be made concerning the moon as a place of origin for the tektites are included. R.T.K.

N64-15285 Naval Observatory, Washington, D.C.
LUNAR MAPPING PROBLEMS
Chester B. Watts. *In* Georgetown U., Washington, D.C. Recent Advances in Astro-Geophysics [1961] p. 66-69 refs. (See N64-15276 07-01)

Maps of the moon's surface have been in existence for a long period of time, showing the locations of physical features in a system of spherical coordinates. Measures of the elevation of the features have also been obtained but, in general, with respect only to neighboring points. The lack of a datum analogous to the surface of the oceans of the earth has presented a serious obstacle to further progress. The means available for solving this problem and the conditions affecting it are reviewed. R.T.K.

N64-15538 Boston U., Mass.
CATALOG OF LUNAR CRATERS V
Gerald S. Hawkins, Peter W. Mitchell, and David D. Friesen. Dec. 1963, 19 p. refs.
(NASA Grant NsG-246-62)
(NASA CR-55547, Res. Rept. 13) OTS: $1.60 ph, $0.80 mf

This catalog gives the selenographic coordinates of all craters observable on a selected portion of the moon's surface. The diameter of the crater, together with comments on shape, is also given. Approximately 25 percent of the craters have been measured previously by other observers. The catalog gives the position found in the present series of measurements and the name adopted by the International Astronomical Union. Author

N64-15876 General Motors Corp., Santa Barbara, Calif. Defense Research Labs.
AN INVESTIGATION OF THE PHENOMENA OF IMPACT FLASH AND ITS POTENTIAL USE AS A HIT DETECTION AND TARGET DISCRIMINATION TECHNIQUE
J. W. Gehring and R. L. Warnica. Apr. 1963, 55 p. refs. Presented at the 6th Hypervelocity Impact Symp., Cleveland, Apr. 30-May 2, 1963
(NASA Contract NAS7-100, JPL Contract 950299, and AFO8(635-2783)

The results of an experimental research program to provide data on the impact radiation associated with the collision of a projectile and a target are presented. This paper analyzes the

phenomenon of impact flash and examines its potential use in two areas. (1) estimation of the impact flash likely to be observed on impact of a lunar probe on the moon's surface, and correlation of impact flash measurements made of an actual lunar impact with physical characteristics of the lunar surface, and (2) selection of hypervelocity impact flash phenomena, which may be remotely observed and which could provide significant information for determining the occurrence of a collision, the damage inflicted upon the target (satellite, ICBM, decoy, etc.), and possibly the identification of the target material.
Author

N64-15891 General Mills Corp., Minneapolis, Minn. Electronics Div.
INVESTIGATION OF SPUTTERING EFFECTS ON THE MOON'S SURFACE Third Quarterly Status Report, 25 Oct. 1963-24 Jan. 1964
G. K. Wehner, D. L. Rosenberg, and C. E. KenKnight. 12 Feb. 1964. 21 p. refs.
(NASA Contract NASw-751, Proj. 89308)
(NASA CR-55720, Rept. 2527) OTS: $2.60 ph, $0.83 mf

Experiments to investigate the influence of bombardment of the lunar surface by the solar wind were continued. Darkening of basalt powder surfaces as a function of energy and duration of hydrogen ion bombardment has been determined. Reflection curves for complex solid mineral surfaces before and after bombardment have been measured. The hole-drilling method of determining sputtering yields has been extended to the oxides of Al, Ti, and Fe.
Author

N64-15896 Texaco Experiment Inc., Richmond, Va.
A THEORETICAL STUDY OF THE PROPAGATION AND ATTENUATION OF ACOUSTIC WAVES IN THE LUNAR SURFACE Interim Report
R. L. Wolf and R. E. Canup. 9 Feb. 1962. 12 p.
(NASA Contract NAS7-100)
(NASA CR-55413, EXP-387, TM-1325) OTS: $1.60 ph, $0.80 mf

Computations were made of the decrease in displacement of waves with frequencies from 25 to 3500 cps in passing through an attenuating medium. The usual attenuation equations were used with constants that have been determined by seismological experiments. Calculations were made at 2-ft intervals for 2 to 20 ft of wave travel.
Author

N64-15900 Boston U., Mass.
CATALOG OF LUNAR CRATERS IV
Gerald S. Hawkins, Peter W. Mitchell, and David D. Friesen. 12 Dec. 1963. 21 p. refs.
(NASA Grant NsG-246-62)
(NASA CR-55536, Res. Rept. 12) OTS: $2.60 ph, $0.83 mf

This catalog gives the selenographic coordinates of lunar craters. The diameters of the craters, together with comments on shape, are also given. Approximately 25 percent of the craters have been measured previously by other observers. The catalog gives the positions found in the present series of measurements and the name adopted by the International Astronomical Union.
R.T.K.

N64-15924 California Inst. of Tech., Pasadena
NEW MEASUREMENTS OF STEEP LUNAR SLOPES
Howard A. Pohn. Repr. from Publ. Astron. Soc. Pacific, v. 75, no. 443, Apr. 1963. p. 186-187. refs.
(NASA Grant NsG-56-60)

A report is presented of investigations of the moon from phase angles of −25° to +25°, using the Mount Wilson 60-inch telescope. These studies have yielded high values for the steepness of lunar crater slopes. A group of 19 craters was selected so as to give a maximum distribution in latitude and longitude, and the measurements made of these craters are included.
R.T.K.

1963

A63-10116
THE INTERNAL CONSTITUTION OF THE MOON.
Zdeněk Kopal (University of Manchester, Dept. of Astronomy, Manchester, England).
(ARS, Lunar Missions Meeting, Cleveland, Ohio, July 17-19, 1962.)
Planetary and Space Science, vol. 9, Oct. 1962, p. 625-638. 46 refs.

Survey of present knowledge concerning the internal structure of the Moon. It is concluded that the relatively low mean density of the lunar globe suggests that the Moon is approximately of the same composition as the terrestrial mantle, but is either deficient in iron, or enriched with some common low-density substance. The mass of the Moon is in a state very close to hydrostatic equilibrium, but deviations from it are significant. Radiogenic heat produced by a spontaneous decay of long-lived radioactive elements should have raised the present temperature of the bulk of the lunar mass to at least 1,000°K even if the Moon originated as an initially cold body. Moreover, these temperatures should at present still be rising. The conductive temperature gradient created by radiogenic heating exceeds the adiabatic gradient of molten rocks by a factor of 10-100 in the greater part of the interior, rendering it almost certain that slow convection currents (with velocities generally less than 1 cm/yr) will provide at least as effective a means of outward heat transport as conduction or radiation. Theoretical considerations indicate, moreover, that stable convection flow can develop only for patterns characterized by spherical-harmonic symmetry of very high order. This flow is probably the main cause for the distribution of mass inside the Moon deviating from hydrostatic equilibrium, as evidenced by the motion of the Moon. The observed disparity in distribution of the lunar maria between the near and far side of the Moon is also likely to be due to this cause. Should the newly-formed Moon have contained a sufficient proportion of such short-lived radioactive elements as I^{129}, Pd^{107}, or Al^{26} to melt it completely in the first 10 million years of its existence, convective cooling would have been capable of bringing about solidification in a comparable period of time. The secular heating should, moreover, have been accompanied by a gradual escape of volatile elements or compounds from the interior. Observable surface manifestations of such processes are briefly discussed.

A63-10221
EVIDENCE FROM THE MOON'S SURFACE FEATURES FOR THE PRODUCTION OF LUNAR GRANITES.
John A. O'Keefe and Winifred Sawtell Cameron (NASA, Goddard Space Flight Center, Greenbelt, Md.)
Icarus, vol. 1, Oct. 1962, p. 271-285. 38 refs.

A consideration of the evidence for granitic rocks from the morphology of the Moon's surface. The displacement of the center of the Moon's visible face with respect to the center of mass is considered evidence of the existence of lunar isostasy. Evidence for characteristic granite landforms, including tholoids and laccoliths, is summarized. It is concluded that the morphology of the Moon's surface does not contradict the notion of the presence of large amounts of acid rock there.

A63-10263
AN ATLAS OF THE MOON'S FAR SIDE: THE LUNIK III RECONNAISSANCE.
Edited by N. P. Barabashov (Kharkov University Observatory, USSR), A. A. Mikhailov (Pulkovo Observatory, USSR), and Iu. N. Lipskii (Moscow University, Sternberg Astronomical Institute, USSR).
New York, Interscience, 1961. 187 p.
$7.00.
Translation of: ATLAS OBRATNOI STORONY LUNY. Moscow, Akademiia Nauk SSR, 1960. Translated by R. B. Rodman (Harvard College Observatory).

Presentation of 20 plates containing 30 pictures of the hidden side of the Moon. These represent the best negatives obtained by the Soviet space probe. Included also are the definitive map of the Moon's far side, a catalog of 498 lunar formations identified, and an account of the working methods used in the analysis of the photographs.

A63-10272
LAND LOCOMOTION ON THE SURFACE OF PLANETS.
M. G. Bekker (General Motors Corp., Santa Barbara, Calif.)
(ARS, Space Flight Report to the Nation, New York, N.Y., Oct. 9-15, 1961.)
ARS Journal, vol. 32, Nov. 1962, p. 1651-1659. 63 refs.

Definition of some fundamental land-locomotion principles and a presentation of methods of approach to the solution of locomotion problems that might exist on extraterrestrial bodies, particularly on the Moon. It is shown that the performance of a locomotion system depends on two sets of factors: (1) the stress-strain relationship that exists in a given terrain, both in the vertical and horizontal directions, and (2) the surface geometry of the terrain under consideration. Equations combining the pertinent terrain and locomotive system characteristics are derived, which permit calculation of performance criteria such as thrust, motion resistance, sinkage, and slope-climbing ability. Problems of obstacle crossing, moving on lunar rocky terrain, as well as experimental work on soil-vehicle systems are discussed. The potential of the developed methods is demonstrated on examples based on assumed lunar soil properties.

A63-10526
LUNAR SURFACE ROUGHNESS FROM CRATER STATISTICS.
C. D. McGillem and B. P. Miller (General Motors Corp., Defense Research Laboratories, Santa Barbara, Calif.)
Journal of Geophysical Research, vol. 67, Nov. 1962, p. 4787-4794.

Compilation of statistical data on the size distribution of craters in the range of sizes visible on lunar maps and photographs. These data are extrapolated to the smaller sizes to make an estimate of the relative frequency of smaller craters. It is found that cumulative crater-size distribution in the visible range of sizes may be approximated by the law $N = AD^{-B}$, where N is the number of craters having diameter greater than D, and A and B are constants. The coefficient A depends upon the total number of craters per unit area, varying from about 1,400 for the maria to 30,000 for the highland regions when D is measured in kilometers and N is in craters per 10^6 km^2. However, it is found that the exponent B is reasonably independent of location on the lunar surface, having a value of about 1.6. Extrapolation using this expression shows that not more than 0.2% of the surface of the maria is covered by craters in the diameter range of one to 100 m, and that even in the highlands, this size range covers less than 6.4% of the area. Thus it would appear that mobility of vehicles is not likely to be jeopardized by these craters.

A63-10529
ENHANCEMENT OF RADAR REFLECTIVITY ASSOCIATED WITH THE LUNAR CRATER TYCHO.
G. H. Pettengill and J. C. Henry (Massachusetts Institute of Technology, Lincoln Laboratory, Lexington, Mass.)
Journal of Geophysical Research, vol. 67, Nov. 1962, p. 4881-4885.

Discussion of some results of radar observation of the lunar crater, Tycho. An unusually strong echo has been observed from the region of the crater. Data supplied by the Millstone radar of MIT is analyzed.

A63-10705
DETERMINATION OF THE POSITION OF THE MOON'S CENTER OF MASS FROM PHOTOGRAPHIC OBSERVATIONS.
N. F. Bystrov (Academy of Sciences, Central Astronomical Observatory, USSR.)
(Astronomicheskii Zhurnal, vol. 39, May-June 1962, p. 527-531.)
Soviet Astronomy, vol. 6, Nov.-Dec. 1962, p. 412-415. Translation.

Discussion of the factors affecting the accuracy of the photographic determination of the position of the Moon's center of mass. The precision of visual and photoelectric measurements of the Moon's limb is compared. A method is suggested for obtaining the position of the center of mass relative to details on the lunar disk.

A63-10811
THE CHEMISTRY OF THE LUNAR SURFACE.
Michael H. Briggs (Victoria University, Dept. of Chemistry, Wellington, New Zealand).

British Interplanetary Society, Journal, vol. 18, July-Aug. 1962, p. 386-389. 40 refs.

Discussion of the possible chemical evolution of the lunar surface, and a review of the evidence for the presence of organic matter on the Moon. It is suggested that the primitive Moon possessed an extensive reducing atmosphere, which was lost slowly and was replaced to some extent by a secondary atmosphere composed of gases leaking through the surface. It is believed that after about 10^9 years the atmosphere and hydrosphere were completely lost, and exposed organic matter became charred and incorporated into sediments. Some organic matter may have become buried by meteoritic dust and may still survive. While the lifetime of the lunar atmospheres appears too short for life to have originated, this possibility cannot be ruled out, although the survival of any of these hypothetical organisms to the present day seems unlikely. The hypothesis that the Moon possessed an extensive hydrosphere and atmosphere, and hence sediments, is compatible with a lunar origin of tektites.

A63-10812

SURFACE ROUGHNESS OF THE MOON.

H. S. Hayre (University of New Mexico, Electrical Engineering Dept., Engineering Experiment Station, Albuquerque, N. M.)

British Interplanetary Society, Journal, vol. 18, July-Aug. 1962, p. 389-391. 15 refs.

Grant No. NsG 129-61.

Correlation of the Davis-Moore-Hayre model for rough terrain with existing lunar radar cross-section data in order to define the word "rough" in terms of the statistical properties of a surface. It is suggested that the angles of incidence for study of radar return from the Moon's surface should be divided into three approximate ranges: 0°-3°, 3°-15°, and 15°-90°. The radar cross section is then analyzed in each range of angles to estimate the order of roughness of the Moon's surface. Moore's separation technique for specular and scatter components is used to obtain a quantized description of almost smooth and rough terrains. The results so obtained are then compared with Evans' definition of a rough sur surface.

A63-10902

ERRORS IN THE MEASUREMENT OF THE TEMPERATURE OF THE MOON.

Eugene A. Burns and R. J. P. Lyon (Stanford Research Institute, Physical Sciences Dept., Propulsion Sciences and Space Sciences Div., Menlo Park, Calif.)

Nature, vol. 196, Nov. 3, 1962, p. 463, 464.

Suggestion of errors in temperature measurements of the Moon arising from the black-body concept of lunar emissivity of Pettit and Nicholson, and from the calculation of temperature using Stefan's law. Inductive errors caused by use of relatively imprecise equipment in the 1930 experiments are pointed out, and more contemporary information is applied in discussing the nature and amount of error.

A63-10909

DIMENSIONAL CORRELATION OF LUNAR MARIA AND TERRESTRIAL OCEAN BASINS.

J. J. Gilvarry (General Dynamics Corp., Astronautics Div., Space Science Laboratory, San Diego, Calif.)

Nature, vol. 196, Dec. 8, 1962, p. 975, 976.

Correction of a difficulty in previously determined correlation curves for lunar craters formed explosively in water. The curves represent a study of the correlation of diameter vs depth for lunar craters of different apparent ages, and include the lunar maria. The correlation, later extended to the terrestrial ocean basins, assumes the former presence of a lunar hydrosphere lasting some milliards of years, affecting the relative dimensions at crater formation.

A63-11000

THE STRUCTURE OF THE MOON'S SURFACE AND A STUDY OF THE FIRST PHOTOGRAPHS OF ITS REVERSE SIDE.

N. P. Barabashov.

(Iskusstvennye Sputniki Zemli, no. 9, 1961, p. 56.)
Planetary and Space Science, vol. 9, Nov. 1962, p. 835-840. 19 refs. Translation.

Analysis of data on the structure of the surface of the Moon obtained by telescopic observations as long ago as 1918, and by the October 1959 photographs of the reverse side of the Moon. The main and most noticeable characteristics of the lunar surface are its low reflective power and the small difference in the color of the various sections of its surface. It is found that the greatest gradation of its albedo (the ratio of the albedo of the darkest places of the lunar surface to the brightest at full-moon) is 1 : 3.46, in addition to which the brightest regions of the Moon's surface have a luminosity of 0.180, and the darkest regions a luminosity of 0.052. From the examination of the processed photographs it is concluded that the reverse side of the lunar surface differs from the side which is visible from Earth, in that it is covered with a multitude of craters, but there are very few seas. The albedo of many regions on the invisible part of the Moon is considerably increased. The bottom of many of the craters is very dark and is similar in darkness to the darkest regions on the visible side of the Moon. On the reverse side of the Moon, to the south-south-east of Humboldt's Sea, there is a vast and very bright luminous ray emanating from a crater surrounded by a bright radiance. The central peak of some craters is so bright that doubts are raised whether luminescence alone could bring this about. Preliminary investigations show that the porosity (microrelief) of the surface of the invisible side of the Moon is apparently the same, if not greater, as that of the visible side, and that the brightness distribution over the surface of the full-moon is almost a straight line.

A63-11651

THE SCATTERING BEHAVIOR OF THE MOON AT WAVELENGTHS OF 3.6, 68, AND 784 CENTIMETERS.

J. V. Evans and G. H. Pettengill (Massachusetts Institute of Technology, Lincoln Laboratory, Lexington, Mass.)

Journal of Geophysical Research, vol. 68, Jan. 15, 1963, p. 423-447. 56 refs.

Demonstration that radio-wave scattering by the Moon is dependent on wavelength. At 3.6 cm some 14% of the surface appears to be covered by structure of the order of the wavelength in size, whereas at 68 cm only 8% of the surface is this rough. The bulk of the surface appears to be smooth and undulating, and describable by means of an exponential law for the lateral correlation of surface height. The mean gradient is found to vary, the wavelength being about 1 in 11 for points spaced by 68 cm and 1 in 7 for points spaced 3.6 cm. Interpreting these results to obtain a value for the reflection coefficient is complicated by the ability of the surface to scatter either more or less favorably than a perfectly smooth spherical surface. The best value that can be obtained from the radar results for the reflection coefficient is 6% at 68 cm, which in turn yields a value for the dielectric constant of 2.8.

A63-11652

RADAR DETERMINATION OF THE ROOT MEAN SQUARE SLOPE OF THE LUNAR SURFACE.

Fred B. Daniels (U.S. Army, Electronics Research and Development Laboratory, Fort Monmouth, N. J.)

(International Scientific Radio Union (URSI)-Institute of Radio Engineers, Joint Meeting, Washington, D. C., Apr. 30-May 3, 1962.)
Journal of Geophysical Research, vol. 68, Jan. 15, 1963, p. 449-453.

Extension of a general theory of radar reflection from planetary surfaces, showing how the slope of the surface profile can be obtained from the autocorrelation function of the signal envelope. The theory is applied to lunar observations made at 440, 151, and 38.25 Mc, and a value of 14° is obtained for the rms slope. The angular power spectrum is found to be wavelength-dependent, except at the short wavelength limit where it depends only on the surface slope.

A63-11724

POWER SUPPLIES FOR MOBILE LUNAR VEHICLES.

Raymond G. Roble, Hwei-Kai Hsi, and George T. Burton (Bendix Corp., Research Laboratories Div., Southfield, Mich.)

American Rocket Society, Space Power Systems Conference, Santa Monica, Calif., Sept. 25-28, 1962, Paper 2525-62. 7 p. 12 refs.

Parametric analysis of the power supplies capable of providing power to two types of mobile lunar vehicles. The two types are an

unmanned vehicle for a 100-Earth-day mission, and a manned vehicle for a 7-Earth-day mission. The hostile lunar environment and its effect on the system parameters are taken into account. Selection of a suitable power supply for the particular missions is made on the basis of the established parameters and design considerations.

A63-11763
INSTRUMENTATION FOR NUCLEAR ANALYSIS OF THE LUNAR SURFACE.
Ralph Monaghan, A. H. Youmans, R. A. Bergan, and E.C. Hopkinson (Dresser Industries, Inc., Research Div., Tulsa, Okla.)
(IRE-NASA-AEC, International Symposium on Space Phenomena and Measurement, Detroit, Mich., Oct. 15-18, 1962.)
IEEE Transactions on Nuclear Science, vol. NS-10, Jan. 1963, p. 183-189.

Proposal of a pulsed, miniature, neutron generator to analyze the lunar surface by nuclear methods, particularly fast neutron activation. Surface data can be derived from the activation gamma-ray spectrum, capture radiation, neutron moderation times, natural gamma rays, and gamma rays scattered from a gamma-ray source.

A63-11859
A CORRUGATED MODEL FOR THE LUNAR SURFACE.
A. E. Gear and J. A. Bastin (University of London, Queen Mary College, Dept. of Physics, London, England).
Nature, vol. 196, Dec. 29, 1962, p. 1305.

Suggestion that a number of previously uncorrelated visual and IR lunar observations may be explained by assuming that the surface of the Moon has indentations, the scale of which is too small to be resolved optically by terrestrial observations. Models similar to that suggested have been found to give good agreement with lunar photographic measurements.

A63-11885
"A LUNAR THEORY REASSERTED" - A REBUTTAL.
J. V. Evans (Massachusetts Institute of Technology, Lincoln Laboratory, Lexington, Mass.)
Journal of Research, Section D - Radio Propagation, vol. 67D, Jan.-Feb. 1963, p. 1-4. 29 refs.
USAF-Army-Navy-supported research.

Presentation of experimental evidence which is not in accord with the theory of Siegel and Senior on the scattering behavior of the Moon at radio wavelengths. Several other theories are reviewed, and new experimental results are discussed.

A63-11886
POINT-TO-POINT COMMUNICATION ON THE MOON.
L. E. Vogler.
Journal of Research, Section D - Radio Propagation, vol. 67D, Jan.-Feb. 1963, p. 5-21. 26 refs.
NASA-sponsored research.

Preliminary study of point-to-point communication systems on the lunar surface, neglecting any atmospheric effects. Ground-wave propagation is assumed over a lunar model consisting of a smooth sphere of homogeneous material in free space, and attenuation curves are presented for a wide range of electromagnetic ground constants. The communication system is described in terms of the power required at the input terminals of the transmitting antenna in order to obtain a given SNR at the receiver. Discussions of antenna considerations and noise effects are presented, and an example is given of a system composed of a Beverage-type wave antenna transmitting towards a vertical electric dipole. For ground conductivities on the order of 10^{-4} to 10^{-3} mho/m, this example indicates an optimum frequency lying in the LF band and a communication range out to somewhat beyond 100 km, depending on the type of service desired.

A63-12088
METEORITE IMPACTS, LUNAR MARIA, LOPOLITHS AND OCEAN BASINS.
R. L. C. Gallant.
Nature, vol. 197, Jan. 5, 1963, p. 38, 39; Discussion, Robert S. Dietz, p. 39, 40. 21 refs.

Brief consideration of the effects of meteoritic impacts on the movement of the Earth. Using simple mathematical relations, and making approximations based on data of past meteorite impacts, a formula is derived for the determination of the weight of a meteorite. The formula also shows to what extent the polar axis of the Earth might be shifted by impact. As an example, it is demonstrated that impact by an asteroid as large as Juno would shift Earth's polar axis by 45'.

A63-12090
DETERMINATION OF RELATIVE AGES OF LUNAR CRATERS BY ALBEDO AND POLARIZATION MEASUREMENTS.
Gilbert Fielder (University of London Observatory, London, England).
Nature, vol. 197, Jan. 5, 1963, p. 69, 70.

Brief derivation of an empirical equation which shows the relationship between the polarization of light reflected by the Moon and the diameter of a lunar crater. Because of intrinsic differences in the albedo of various rocks on the Moon, and because the initial degree of roughness of the rocks will certainly differ from point to point, the equations derived are only statistical. On the basis of these relationships, it is concluded that the largest craters are the oldest.

A63-12166
THE MEASUREMENT OF LUNAR ALTITUDES BY PHOTOGRAPHY. I - ESTIMATING THE TRUE LENGTHS OF SHADOWS.
G. Fielder (University of London Observatory, London, England).
Planetary and Space Science, vol. 9, Dec. 1962, p. 917-928.
USAF-supported research.

Discussion of the known sources of error in the apparent length of a lunar shadow recorded photographically and measured with a microdensitometer. The treatment is general but is illustrated by reference to sunrise shadows of various lengths cast by the lunar Straight Wall. It is shown that measurements of shadow lengths made between half-density points of a microdensitometric scan along a shadow may contain systematic errors due to the non-linearity of the characteristic of the photographic emulsion. The most important sources of systematic-error are seeing (especially in the case of short shadows), penumbrae, and uncertain selenographic coordinates. Other errors, due to seeing, effects at a shadow-tip, and procedures of measurement, are also important but probably apply in a more nearly random manner.

A63-12167
THE MEASUREMENT OF LUNAR ALTITUDES BY PHOTOGRAPHY. II - SOME MEASUREMENTS ON THE LUNAR STRAIGHT WALL.
G. Fielder (University of London Observatory, London, England).
Planetary and Space Science, vol. 9, Dec. 1962, p. 929-938.
USAF-supported research.

Presentation of data on the lengths of shadows cast by the lunar Straight Wall and their corrections, where possible, for systematic errors and relative altitudes. All known sources of error are taken into account to compute the most probable error in a result, which is commonly ±10% of the altitude. The results from the photographic method are compared with visual estimates. It is shown that the top of the Straight Wall is level to within ±100 m. For several different shadow lengths, the greatest relative altitude is near to the center of the Wall, and is of the order of 400 m. The mean relative altitude of the Straight Wall is ~300 m for short shadows and ~380 m for long shadows.

A63-12170
THE NATURE OF SOME OF THE CHARACTERISTIC DETAILS ON THE MAP OF THE REVERSE SIDE OF THE MOON.
A. V. Khabakov.
(Iskusstvennye Sputniki Zemli, no. 9, 1961, p. 52.)
Planetary and Space Science, vol. 9, Dec. 1962, p. 961-968.
Translation.

Discussion of the principal features of the reverse side of the Moon, based on interpretations of the first photographs taken. Among the objects recognized are the following: (1) rounded and

large dark spots; (2) zones with groups of large dark and luminous spots arranged in parallel; (3) extensive, but not clearly defined, grey regions with indefinite, and often complex outlines; (4) smaller circular or annular dark or luminous spots; and (5) bright spots and groups of spots and band traces of a radial structure. On the basis of these determinations, a map is constructed which offers a qualitative evaluation of the difference in brightness of the principal features. It is confirmed that an ordered arrangement of features in the form of rows, chains, or festoons exists in some places on the reverse side of the Moon.

A63-12228

THERMAL ASPECTS OF LONG-TERM STORAGE OF PROPELLANTS ON THE LUNAR SURFACE.

Tibor Buna (Martin-Marietta Corp., Baltimore, Md.)

American Rocket Society, Annual Meeting, 17th, and Space Flight Exposition, Los Angeles, Calif., Nov. 13-18, 1962, Paper 2690-62. 36 p. 15 refs.

Development of a method for the prediction of vaporization rates, mean temperatures, and temperature amplitudes of insulated propellants exposed to stabilized periodic heating in the lunar environment. It is shown that, with modest investments in required insulation weights, propellant temperature levels comparable to Earth-ambient temperatures may be maintained indefinitely on the lunar surface, and boil-off rates of cryogenic propellants may be kept within acceptable limits for storage time up to several lunar cycles. The feasibility of artificially modifying the effective reflectivity of the lunar surface is established, and the effect of this modification on performance is evaluated. The relative effects of surface optical properties, insulation heat-transfer mechanisms (conduction vs radiation), and spatial and temporal distribution of the environmental radiation intercepted by the container are discussed.

A63-12465

SCIENTIFIC OBJECTIVES OF LUNAR EXPLORATION.

Robert Jastrow (NASA, Goddard Space Flight Center, Greenbelt, Md. and NASA, Lunar Science Subcommittee, Washington, D.C.)

(American Astronautical Society, Lunar Flight Symposium, New York, N.Y., Dec. 27, 1960.)

IN: Lunar Exploration and Spacecraft Systems. New York, Plenum Press, 1962. p. 1-10.

Brief review of the lunar science program for the next 10 years. The program includes: (1) extensive scientific exploration of the Moon, including mapping and surface-composition analyses; (2) unmanned scientific observatories; and (3) instrumented probes. The current state of knowledge regarding the Moon as a planetary body is surveyed, and specific scientific objectives are discussed.

A63-12557

LUNAR MANUFACTURING.

Bruce B. Carr (Callery Chemical Co., Callery, Pa.)

American Rocket Society, Annual Meeting, 17th, and Space Flight Exposition, Los Angeles, Calif., Nov. 13-18, 1962, Paper 2689-62. 6 p.

Examination, from a process viewpoint, of the possibility of producing useful materials on the Moon. Although water would be the most desirable raw material, the actual requirement for either life support or propellant use is primarily for oxygen, based on weight of material required. Several processes are considered for producing water or oxygen on the Moon. The approach suggested is not completely dependent on the present knowledge of Moon composition, yet it can take advantage of the optimum raw material, water, if found. Processes considered vary in technological difficulty from simple rock dehydration to reduction of silicates, the objective being maximum simplicity of operation even at a cost of increased power requirement and technical problems. The criteria of weight payout time is suggested for process evaluation. This is the time required to produce a weight of product equal to the weight of plant required. A weight payout time of three or four months is estimated for an underground reduction process designed to minimize labor and rock handling.

A63-12627

LUNAR SURFACE AND SUBSURFACE MAGNETIC SUSCEPTIBILITY INSTRUMENTATION.

Edgar M. Bollin (California Institute of Technology, Jet Propulsion Laboratory, Pasadena, Calif.)

(Institute of Radio Engineers-National Bureau of Standards-American Institute of Electrical Engineers-National Science Foundation, International Conference on Precision Electromagnetic Measurements, Boulder, Colo., Aug. 14-17, 1962.)

IRE Transactions on Instrumentation, vol. I-11, Dec. 1962, p. 102-106.

Contract No. NAS 7-100.

Study of multicoil induction measurements of the lunar surface and subsurface magnetic susceptibility. Improvement of the accuracy and logging ability of various probe configurations is considered. Special boundary conditions of high vacuum, extreme ambient temperature variation, restriction to mechanically passive systems, simple electronics, low power, and light weight all contribute to degradation of the accuracy of the instrument. Measurements in the range of 10 to 100,000 micro-oersted/gauss are of interest. Nonsedimentary rocks range from 40 to 1,000 micro-oersted/gauss. The presence of nickel-iron meteoritic material may extend the range beyond the present limits of measurement. The determination of the presence or absence of meteoritic material is necessary to validate not only the accuracy of the susceptibility measurement, but also the accuracy of low-level magnetometer measurements.

A63-12743

DIE BESCHAFFENHEIT DER MONDOBERFLÄCHE [THE COMPOSITION OF THE LUNAR SURFACE].

Kurd von Bülow.

Weltraumfahrt, vol. 13, Nov.-Dec. 1962, p. 161-164. In German.

Discussion of the composition of the lunar surface as it would affect manned landing (and locomotion) on the Moon. The results of the analysis indicate that firm and somewhat smooth areas can be expected only in the relatively dark (dust-poor) terrae regions; in the lighter-colored areas, dust and ash accumulations can be expected. Maria surfaces are thought to be sharp-edged, nonuniform in composition, and subject to faults. Avalanches of the dust banks from steep slopes and near rock crevices can be caused by sudden shocks. The dust factor, however, should be taken into account at any spot on the lunar surface, and may contribute considerably to the perils of locomotion -e.g., danger areas may be hidden below a layer of dust.

A63-12763

DYNAMIC PENETRATION STUDIES IN CRUSHED ROCK UNDER ATMOSPHERIC AND VACUUM CONDITIONS.

David J. Roddy, John Rittenhouse, and Ronald F. Scott (California Institute of Technology, Pasadena, Calif.)

American Rocket Society, Annual Meeting, 17th, and Space Flight Exposition, Los Angeles, Calif., Nov. 13-18, 1962, Paper 2713-62. 11 p. 10 refs.

Description of a device to study dynamic penetration in air and in a high-vacuum (10^{-5} mm Hg) condition. Possible lunar surface exploration applications are indicated. The apparatus is designed to drop cylindrical, metal rods, pointed on one end, into cohesionless, crushed-rock material. Dynamic penetration is studied as a function of several particle sizes and mixtures of these particle sizes. Other factors considered are the density of packing, probe dimensions, vacuum pressure, and vacuum degassing rates. Experimental results show that the density of packing of the crushed-rock particles is the dominant factor affecting the dynamic penetration. The maximum penetration occurs in air in the crushed rock with low-density packing. The minimum penetration occurs in air in densely packed material. Dynamic penetration in vacuum for the low-density and high-density packing lies between the results of penetration in air for the same packing conditions. At vacuum pressures above approximately 0.1 mm Hg all penetration values approach the air penetration measurements.

A63-12838

THE EARLY HISTORY OF THE MOON AND THE EARTH.

H. Alfvén (Royal Institute of Technology, Stockholm, Sweden).

Icarus, vol. 1, Jan. 1963, p. 357-363.

Presentation of arguments for the view that the Moon originally was a planet, which was captured by the Earth. According to

Gerstenkorn, the capture took place in a retrograde orbit, which by tidal action was changed to a polar orbit and later to the present direct orbit. During this process the Moon reached the Roche limit and a breakup took place. The results for the Earth (possibly the formation of continents) and for the Moon (possibly the formation of the lunar craters) are discussed.

A63-12840
ON THE DISTRIBUTION OF LUNAR MARIA AND THE SYNCHRONOUS ROTATION OF THE MOON.
Douglas B. Nash (California Institute of Technology, Jet Propulsion Laboratory, Div. of Space Sciences, Pasadena, Calif.)
Icarus, vol. 1, Jan. 1963, p. 372, 373.
NASA-supported research.

Presentation of a hypothesis as an alternate to Turski's to explain the predominance of maria on the near side of the lunar surface. It is assumed that the Moon in the past was not maintaining the same hemisphere toward the Earth, and that it was bombarded on one side by a sudden swarm of meteors which added considerably to the mass of the Moon. According to this hypothesis the maria are scars left by the impact of a swarm of bodies which added mass to one hemisphere of the Moon only, and that hemisphere faces the Earth because it has greater mass and, therefore, is attracted more strongly by the Earth's gravitational field.

A63-13069
AN UNSOLVED ASTROMETRICAL PROBLEM.
A. A. Iakovkin (Kiev State University, Astronomical Observatory, Kiev, Ukrainian SSR).
(Astronomicheskii Zhurnal, vol. 39, July-Aug. 1962, p. 736-745.)
Soviet Astronomy, vol. 6, Jan.-Feb. 1963, p. 573-579. 22 refs.
Translation.

Discussion of the need for developing methods for computing the coordinates of the center of mass of the Moon from observational data. Observations at six points are compared and yield direct results, depending on no prior hypothesis. A description is given of four models of the Moon used to reduce heliometric observations; the models explain certain observed facts.

A63-13172
TOPOGRAPHY AND TECTONICS OF THE LUNAR STRAIGHT WALL.
G. Fielder (University of London Observatory, London, England).
Planetary and Space Science, vol. 11, Jan. 1963, p. 23-30.

Investigation of the topography and the nature of the Straight Wall region of the Moon. Data are used from the following sources: (1) measurement of sunrise shadows, (2) measurement of the width of the face of the Straight Wall at sunset, (3) photometric measurements of the slope of the surface in the immediate vicinity of the Wall, and (4) photographic and visual observations. The Wall itself is found to be a dip-slip fault, with the upthrow dipping gently away from the fault. The dominant tectonic forces in the region are undoubtedly due to igneous activity.

A63-13247
THE MEASURE OF THE MOON.
Ralph B. Baldwin (Oliver Machinery Co., Grand Rapids, Mich.)
Chicago, University of Chicago Press, 1963. 580 p.
$13.50.

Through a detailed discussion of terrestrial meteoritic craters, related crater-forming mechanics, and Earth-lava flows, the evolution of the Moon and the meaning of its surface markings are linked with those of the Earth. In an attempt to establish a logical sequence of happenings on an unambiguous time scale, a history of the Moon, Earth, and Earth-Moon system is presented which is consistent with most of the lunar markings and certain terrestrial formations. Tables, maps, figures, and illustrations support the text, offering a history of the Moon from the time it reached its present size - 4.5 billion years ago - until now. Included in the appendices are derivations of the relationship between the distance of the Moon and geologic time, and the lunar tidal bulge as a function of the Moon's distance.

A63-13334
FACILITIES FOR MANNED SPACECRAFT DEVELOPMENT: MSC TEST FACILITIES.
Joseph N. Kotanchik and H. Kurt Strass (NASA, Manned Spacecraft Center, Systems Evaluation and Development Div., Houston, Tex.)
Astronautics and Aerospace Engineering, vol. 1, Feb. 1963, p. 78-81.

Discussion of major facilities now in planning or design phase for the manned spaceflight program, with particular attention to environmental acceleration and structural facilities. Both a space and lunar-surface environment-simulation chamber and a vacuum chamber are described. The flight acceleration facility will be used chiefly for training astronauts in spacecraft operation. It will also be used for physiological testing of crew personnel, and acceleration testing of crew equipment and operating systems. In addition, a thermochemical test area and a structures and materials laboratory are discussed.

A63-13342
PRELIMINARY LOCOMOTION ANALYSIS OF LUNAR SURFACE VEHICLES.
W. B. Sponsler (Northrop Corp., Northrop Space Laboratories, Hawthorne, Calif.)
IN: Symposium on Ballistic Missile and Space Technology, 7th, Transactions, Volume I. Colorado Springs, Colo., Aug 13-16, 1962. Los Angeles, Aerospace Corp.; USAF, Systems Command, Office of the Deputy Commander for Aerospace Systems, 1962. p. 23-52. 14 refs.

Preliminary study of vehicular mobility on the lunar surface. Basic modes of controlled locomotion are discussed, and the most promising (rigid and flexible wheels and tracks) are analyzed. The effects of surface characteristics, vehicle weight, and tread configuration are related to traction, rolling resistance, range, obstacle capability, and acceleration. Typical examples are compared, varying the lunar surface parameters to develop a relative evaluation and to present a method for further analysis. The necessity for slow speeds and the effects of lunar environment upon traction, ride, stability, braking and other factors are considered. On the basis of the study it is concluded that the semirigid wheel appears practical for strong surfaces and for lightweight, short-range vehicles on weak soils. For heavy vehicles on weak surfaces, the choice between wheel and track is seen to be less pronounced, and, while favoring the large flexible wheel, it could swing to the track for specialized applications or for unusual surface conditions.

A63-13343
PENETRATION STUDIES OF SIMULATED LUNAR DUST.
R. D. Rowe and E. T. Selig (Illinois Institute of Technology, Armour Research Foundation, Soil Mechanics Section, Chicago, Ill.)
IN: Symposium on Ballistic Missile and Space Technology, 7th, Transactions, Volume I. Colorado Springs, Colo., Aug. 13-16, 1962. Los Angeles, Aerospace Corp.; USAF, Systems Command, Office of the Deputy Commander for Aerospace Systems, 1962. p. 53-72.

Experimental investigation of the static and dynamic penetration resistance of simulated lunar dust in a hard vacuum environment. Basically, two types of tests are considered: (1) dynamic penetration of rod-shaped projectiles dropped into the dust, and (2) static bearing tests with small blocks resting on the surface of the dust. Atmospheric and low-vacuum tests are conducted with specimens of finely ground silica covering a range of densities. The effects of density charge and absolute pressure on penetration are studied. It is seen that, while the nature of the behavior is somewhat different, both static and dynamic penetration resistances are significantly dependent on the initial specimen density and on the vacuum levels, increasing with an increase in density or a decrease in density pressure. It is pointed out that the material would have greater strength under lunar environmental conditions than under terrestrial atmospheric conditions. At low-pressure levels, the dust increases in strength because of the removal of the adsorbed monomolecular film or gas surrounding the particles.

A63-13523
RADAR REFLECTIONS FROM THE MOON AT 425 Mc/s.
George H. Millman and Fred L. Rose (General Electric Co., Syracuse, N. Y.)

(International Scientific Radio Union and Institute of Radio Engineers, Joint Meeting, Washington, D.C., Apr. 30, 1962.)
Journal of Research, Section D - Radio Propagation, vol. 67D, Mar.-Apr. 1963, p. 107-117. 20 refs.
Contract No. AF 30(602)-2244.

Discussion of the characteristics of the lunar surface deduced from radar-lunar measurements conducted at the USAF Trinidad Test Site during 1960. Evidence is presented which tends to confirm that, at 425 Mc, the front portion of the Moon is a comparatively smooth reflector, while the back portion behaves as a rough scatterer. The pulse decay of the average envelope of lunar echoes is found to follow the slope of the Lommel-Seeliger scattering law. From the cumulative probability distributions of the total cross section of the Moon measured on two different days, it is indicated that 50% of the total cross-sectional measurements were less than 5.0×10^{11} to 8.5×10^{11} m^2 or 117.0 to 119.3 db above 1 m^2. Statistical data, such as the probability density functions of the total lunar echo amplitude and the autocorrelation function, are also presented. The power-density spectrum computed from the autocorrelation function is compared with the theoretical Doppler spread resulting from the libration of the Moon.

A63-13783
INVESTIGATION OF THE MAGNETIC FIELD OF THE MOON.
Sh. Sh. Dolginov, E. G. Eroshenko, L. N. Zhuzgov, and N. V. Pushkov.
(Akademiia Nauk (USSR), Geomagnetizm i Aeronomiia, no. 1, 1961, p. 21-29.)
AIAA Journal, vol. 1, Feb. 1963, p. 514-516. Translation.

Discussion of the experiment and the experimental data concerning the field of the Moon which were obtained during the flight of the second Soviet cosmic rocket (1959 Xi). The first magnetic field measurements near the Moon made it possible to establish that the Moon does not have a notable magnetic field. The Moon's dipole magnetic moment can be only less than 1/10,000 of the Earth's magnetic moment. This result gives evidence in favor of the contemporary hypothesis of the origin of the Earth's magnetic field. In addition to making the lower boundaries more precise, subsequent experiments may provide information on whether the Moon had a magnetic field in the past, and on the genesis of its surface and its cosmogonic history.

A63-13866
THE ORIGIN AND EVOLUTION OF THE SOLAR SYSTEM.
Harold C. Urey (University of California at San Diego, La Jolla, Calif.)
IN: Space Science. New York, John Wiley and Sons, Inc., 1963, p. 123-168. 67 refs.

Consideration of a possible model of the origin of the solar system based on a study of the Moon, the meteorites, and the system's chemical constitution. The physical characteristics of the Moon are discussed. The surface features are described in relation to the origin of the craters. It is pointed out that meteorites acquired most of their chemical composition and physical structure during the process of the evolution of the solar system. The composition of iron and stone meteorites is discussed. Tables are provided which list the abundance of metals in meteorites and in the Sun. The density of the planets is estimated. Theories concerning the origin of meteorites are briefly reviewed. Considered also are the general problems of the origin of stars, and the origin of solar nebulae. The model advanced is seen to follow Jeans instability of a rotating mass as a means of securing a solar nebula, and the gravitational formulas of Jeans, of Chandrasekhar, and of Bel and Schatzman. It is shown that this model accounts for the differing compositions of the planets and the composition of the Moon. It is found that the model can explain certain properties of meteorites, as well as other basic requirements of the problem, such as those arising from considerations of magnetic fields.

A63-13877
THE SURFACE OF THE MOON.
Gerard P. Kuiper (University of Arizona, Tucson, Ariz.)
IN: Space Science. New York, John Wiley and Sons, Inc., 1963, p. 630-649. 18 refs.

Presentation of the observed macrostructure and microstructure characteristics of the lunar surface. It is seen that the telescope reveals the following types of lunar terrain: (1) dark areas, which comprise the so-called maria and the "flooded" crater bottoms; (2) bright adjacent areas covered with irregular masses of debris; and (3) the highlands, or terrae, which differ from the maria not merely in brightness and lack of gross or systematic structure features, but also contain vastly more lunar craters. Other classes of subsidiary features, that are structurally related to the terrain in which they occur, are described. It is pointed out that the microstructure of the Moon is also accessible to observation. The photometric, colorimetric, and particularly the polarization properties of the different lunar provinces broadly define the microstructure for dimensions of 10^{-5} to 10^{-1} cm. Photographs of different lunar areas, as well as a schematic map of the reverse side of the Moon, are provided. The development of the Moon and its observable surface is interpreted.

A63-13880
VISUAL REQUIREMENTS FOR LANDING ON THE MOON.
Jack E. Conklin (Hughes Aircraft Co., Culver City, Calif.)
Human Factors, vol. 4, Dec. 1962, p. 335-342. 26 refs.

Investigation of the visual requirements for landing a shuttle spacecraft on the surface of the Moon and subsequently achieving rendezvous with the command module in orbit. The major questions studied are: (1) the capability of the astronaut to perceive Moon landmarks while on orbit in order to detect and identify a desired landing area; and (2) the capability of perceiving the command module from the Moon during all phases of its orbit from lunar horizon to entry into the lunar shadow. The properties of the Moon landmarks are examined in terms of size, contrast, and velocity of the moving imagery. Stellar magnitude and luminance data are calculated for the command module and for Earth as seen from the Moon for different phase angles and albedos. The effects of glare on the discrimination of the command module are discussed.

A63-14380
EXPLORATION OF THE MOON IN THE U.S.S.R.
A. A. Mikhailov (Academy of Sciences, Central Astronomical Observatory, Pulkovo, USSR).
(International Astronomical Union-Douglas Aicraft Co., Inc., International Symposium on Space Age Astronomy, Pasadena, Calif., Aug. 7-9, 1961.)
IN: Space Age Astronomy. New York, Academic Press, Inc., 1962, p. 462-471; Discussion, p. 471-475.

Description of the observation of Kozyrev of a cloud of a gas containing C_2, issuing from crater Alphonsus and a detailed account of the observation of the reverse of the Moon. Included are reproductions of original television recordings of lunar photographs, a map of the reverse side of the Moon, and a composite drawing of the Moon's external perspective.

A63-14381
THE EXPLORATION OF THE MOON, THE PLANETS, AND INTERPLANETARY SPACE.
A. R. Hibbs (California Institute of Technology, Jet Propulsion Laboratory, Pasadena, Calif.)
(International Astronomical Union-Douglas Aircraft Co., Inc., International Symposium on Space Age Astronomy, Pasadena, Calif., Aug. 7-9, 1961.)
IN: Space Age Astronomy. New York, Academic Press, Inc., 1962, p. 476-493.
Contract No. NASw-6.

Description of the orbits, instrumentation, and experiments to be carried out with Ranger 1 thru 5, and the Surveyor and Mariner spacecrafts.

A63-14382
PROBLEMS OF SURFACE EXPLORATION OF THE MOON AND THE PLANETS.
Robert K. Roney (Hughes Aircraft Co., Culver City, Calif.)
(International Astronomical Union-Douglas Aircraft Co., Inc., International Symposium on Space Age Astronomy, Pasadena, Calif., Aug. 7-9, 1961.)

IN: Space Age Astronomy. New York, Academic Press, Inc., 1962, p. 498-500.

Brief discussion of guidance accuracy, environmental problems, and the problems presented in landing on an airless planet or one with an atmosphere.

A63-14506

STRUCTURE OF THE MOON'S SURFACE AND INVESTIGATION OF THE FIRST PHOTOGRAPHS OF ITS FAR SIDE.

N. P. Barabashov.

(Iskusstvennye Sputniki Zemli, no. 9, 1961, p. 56-61.)

AIAA Journal, Russian Supplement, vol. 1, Mar. 1963, p. 744-747. 22 refs. Translation.

[See Accession no. A63-11000, 03-05]

A63-14534

AN ORIGIN OF THE MOON BY ROTATIONAL FISSION DURING FORMATION OF THE EARTH'S CORE.

Donald U. Wise (Franklin and Marshall College, Dept. of Geology, Lancaster, Pa.)

Journal of Geophysical Research, vol. 68, Mar. 1, 1963, p. 1547-1554. 31 refs.

Discussion of Darwin's hypothesis of lunar origin from a rapidly rotating Earth. It is suggested that the hypothesis can be modified by substitution of the excessive rotation rate and unstable spin by conservation of angular momentum during formation of the Earth's core for Darwin's tidal resonance mechanism. Criticisms which caused rejection of the older hypothesis are considered in light of this modification and subsequent discoveries and ideas.

A63-14575

THE CRATERS IN THE LUNAR WALLED PLAIN PTOLEMAEUS.

Ann Palm and Robert G. Strom (University of California, Space Sciences Laboratory, Berkeley, Calif.)

Planetary and Space Science, vol. 11, Feb. 1963, p. 125-134. 12 refs.

Grant No. NsG-145-61.

Measurement, from lunar photographs, of diameters of craters in the lunar walled plain Ptolemaeus and in the vicinal equal-area terrae (highland surfaces). Statistical analyses of the data lead to the conclusion that the "ghosts," which are partially submerged craters, and the post-Ptolemaean craters came from distinctly different populations. On the basis of the relative surface densities, age, and frequency distribution of the total Ptolemaean and adjacent terrae craters, it is inferred that these craters may have had a similar history.

A63-14576

THE MOON'S FIRST DECIMETER.

K. J. K. Buettner (University of Washington, Seattle, Wash.)

Planetary and Space Science, vol. 11, Feb. 1963, p. 135-148. 26 refs.

Contract No. NAS 7-100; JPL Contract No. N-33561.

Discussion of the possible composition of the surface layer of the Moon, pointing out possible lunar conditions which could affect the interpretation of thermal and electromagnetic radiation measurements. These possibilities are considered: that the top layers may be partially permeable to infrared emission; that the white surface areas, such as the crater Aristarchus, permit solar radiation to penetrate below the surface; that, based on laboratory measurements, the heat conductivity of dust decreases with air pressure, and at low pressures with temperature; that, also from laboratory measurements, the specific heat of rocks depends on the cube root of the temperature rather than on the temperature itself; and that ionizing rays could have liberated metals atoms in the lunar surface material, thus raising the electrical conductivity.

A63-15151

SURFACE MATERIAL OF THE MOON.

Charles R. Warren (U.S. Geological Survey, Washington, D.C.)

Science, vol. 140, Apr. 12, 1963, p. 188-190. 11 refs.

Proposal of a theory concerning the surface material of the Moon in order to explain, primarily, the surface property of backscattering much more light in the direction of the light source than in any other direction. Dominant theories explaining this effect are briefly outlined, and their defects are considered. The requirements for a feasible hypothesis are discussed, one of the important elements being the geometry of the material of the lunar surface. Based on such theoretical considerations, and on experimental evidence, a theory is presented, which suggests that the surface of the Moon is probably covered by an open-texture, highly porous maze or meshwork of randomly oriented linear units with or without nodes. The structure could be a mesh or a "Tinker-Toy" structure in which opaque units (nodes) are spaced apart by thinner rods, or it might resemble that of snowflakes or reindeer moss.

A63-15512

SELENOLOGICAL IMPLICATIONS OF THE SOUTH-AUSTRALIAN RING STRUCTURES.

V. A. Firsoff.

Nature, vol. 198, Apr. 6, 1963, p. 78, 79. 10 refs.

Brief consideration of the theory that explains, in part, the different surface features of the Earth and Moon by the two main factors which differentiate geological and selenological processes. These are the absence in the latter of surface water, and gravity reduced by a factor of six. A discussion is given on the large ring structures in a Pre-Cambrian volcanic complex of South Australia, as described by Crawford.

A63-15885

DYNAMIC PENETRATION STUDIES IN CRUSHED ROCK UNDER ATMOSPHERIC AND VACUUM CONDITIONS.

David J. Roddy, John B. Rittenhouse, and Ronald F. Scott (California Institute of Technology, Pasadena, Calif.)

AIAA Journal, vol. 1, Apr. 1963, p. 868-873.

Contract No. NASw-6; NsG-56-60.

[See Accession no. A63-12763, 07-29]

A63-15948

RECOVERY OF WATER OR OXYGEN BY REDUCTION OF LUNAR ROCK.

Bruce B. Carr (Callery Chemical Co., Callery, Pa.)

AIAA Journal, vol. 1, Apr. 1963, p. 921-924.

[See Accession no. A63-12557, 06-29]

A63-16361

PROPERTIES OF THE LUNAR SURFACE AS REVEALED BY THERMAL RADIATION.

R. W. Muncey (Commonwealth Scientific and Industrial Research Organization, Div. of Building Research, Melbourne, Australia).

Australian Journal of Physics, vol. 16, Mar. 1963, p. 24-31. 17 refs.

Calculation of the uniform lunar surface corresponding to the observed optical values, using the assumption that the thermal properties of radiation from the Moon are proportional to the temperature. Possible mixed surfaces are evaluated and examined to estimate the likely variation in microwave radiation. By comparing the calculations with observed results, it is shown that the most probable surface consists partly of rock or gravel overlaid by a thin layer of fine dust, and partly of areas with dust extending beyond the depth from which the microwave radiation emanates.

A63-16753

RADAR DETERMINATION OF LUNAR SLOPES: CORRECTION FOR THE DIFFUSE COMPONENT.

Fred B. Daniels (U. S. Army, Electronics Research and Development Laboratory, Fort Monmouth, N. J.)

Journal of Geophysical Research, vol. 68, May 1, 1963, p. 2864, 2865.

Presentation of corrections to a previously determined rms slope of the lunar surface computed from the autocorrelation function of the radar echo. It is shown that the measured autocorrelation function contained a significant amount of relatively HF energy from the diffuse component of the scattering which was not corrected for in the original formulation of the theory.

A63-16994
DYNAMIC ANALYSIS FOR LUNAR ALIGHTMENT.
A. P. Cappelli (North American Aviation, Inc., Space and Information Systems Div., Downey, Calif.)
AIAA Journal, vol. 1, May 1963, p. 1119-1125.

Presentation of an analytical procedure that describes the landing dynamics of a lunar alightment vehicle. The motion of an impacting vehicle is defined by the classical Eulerian equations of rigid body motion. These equations are integrated numerically by the digital computer to obtain particular solutions. Landing stability curves for a typical lunar vehicle are derived from the particular results obtained with this analytical procedure. An idealized model representing a typical lunar vehicle is used in making the analysis. This model incorporates the use of three crushable landing legs to accomplish the dissipation of kinetic energy at impact. Included is a discussion of the alightment concept and the effects of lunar-surface characteristics. The results of vehicle drop tests are reported.

A63-17234
SURFACE PROPERTIES OF THE MOON.
Ernst J. Öpik (University of Maryland, Dept. of Physics, College Park, Md.)
IN: Progress in the Astronautical Sciences. Vol. I. Amsterdam, North-Holland Publishing Co., 1962, p. 215-260. 56 refs.
Grant No. NsG 58-60.

Critical study of some of the surface properties of the Moon, including the origin of the lunar craters. The photometric properties of the Moon are reviewed. The phase law points to a rough surface covered with opaque grains or elevations. The increase in contrast of the bright rays and dark spots near Full Moon can also be explained by a greater or smaller degree of roughness of these markings, as compared with the average surface. The dynamical shape of the Moon as characterized by its principal moments of inertia would be equivalent to an uncompensated bulge of 1.1 km directed toward the Earth, and one of 0.8 km at right angles in the equatorial plane; it cannot be easily interpreted as a "frozen-in" fossil tidal bulge. A rediscussion of old and new observational data shows that, contrary to widespread opinion, the geometrical shape of the lunar surface is closer to spherical than the dynamical shape of the Moon as a whole. The average level of the maria is 2.52 ± 0.13 km below that of the continents. The density of the lunar atmosphere, probably much less than 10^{-16} gm/cm^3, can exceed that of interplanetary space by two-to-three orders of magnitude at most. It is an exosphere of no permanent status, entirely determined by the balance of incoming and incoming and outgoing material. The lunar dust layer equally covers the mountain slopes and the plains, and cannot possess any appreciable degree of fluidity. Its formation and limited transport by meteoric bombardment are considered. The probable origin and structure of the Moon are discussed from the standpoint of accretion from solid fragments. In the light of the collisional probability theory of accretion from fragments, a consistent model requires that the Moon was formed from a ring of fragments orbiting the Earth, and not directly from interplanetary material.

A63-17303
RADIO-BRIGHTNESS DISTRIBUTION ON THE LUNAR DISK AT 0.8 CM.
A. E. Salomonovich and B. Ia. Losovskii (Academy of Sciences, P. N. Lebedev Physics Institute, Moscow, USSR).
(Astronomicheskii Zhurnal, vol. 39, Nov.-Dec. 1962, p. 1074-1082.)
Soviet Astronomy, vol. 6, May-June 1963, p. 833-839. 11 refs. Translation.

Presentation of the results of the first observations of the Moon, at 0.8 cm with a radio telescope of high resolving power. The construction of meridional and equatorial distributions of the constant component of the brightness temperature shows that a decrease takes place in the radiating power from center to limb, corresponding to an effective dielectric permeability $\varepsilon_{eff} < 20$. A comparison of the observed and computed values of the phase lag provides support for a single-layer model.

A63-17305
THE EMISSIVITY OF THE MOON AT CENTIMETER WAVELENGTHS.
V. D. Krotikov and V. S. Troitskii (Gor'kii University, Radiophysics Scientific Research Institute, Gor'kii, USSR).
(Astronomicheskii Zhurnal, vol. 39, Nov.-Dec. 1962, p. 1089-1093.)
Soviet Astronomy, vol. 6, May-June 1963, p. 845-848. Translation.

Analysis of accurate measurements of the lunar radio temperature averaged over the disk which lead to a value of the constant component at 3.2 cm of $(210 \pm 5)^{\circ}$K. Calculation of the emission from an absolutely black moon for a temperature distribution of the form $\eta(\psi) = \cos^{1/2}\psi$ and the most probable values of night and day surface temperatures (125° and 391°K) yield 218°K. It follows, therefore, that at $\lambda = 3.2$ cm the surface of the moon is close to being absolutely black. This, in particular, may be true in two limiting cases: if dense lunar rock is very rough for 3.2-cm waves, or if the surface is smooth and consists of very porous, light material. There are reasons to consider the lunar surface to be so smooth that Fresnel's reflection formulas still hold at 3.2 cm. It then follows from experimental data that the reflection coefficient at centimeter wavelengths is less than 2% for normal incidence, a dielectric constant for the surface material of $1.1 \leq \varepsilon \leq 1.7$, and a density of $0.2 \leq \rho \leq 0.89$ g/cm^3. This is in good agreement with the values of the dielectric constant and density obtained previously from other data.

A63-17309
MEASUREMENT OF THE POLARIZATION OF LUNAR RADIO EMISSION ON A WAVELENGTH OF 3.2 CM.
N. S. Soboleva (Academy of Sciences, Main Astronomical Observatory, Pulkovo, USSR).
(Astronomicheskii Zhurnal, vol. 39, Nov.-Dec. 1962, p. 1124-1126.)
Soviet Astronomy, vol. 6, May-June 1963, p. 873-875. Translation.

Discussion of linear polarization of lunar radio emission detected at 3.2 cm. The observations were made with the large Pulkovo radio telescope, whose directional pattern is 1' x 40' at an altitude of 10°. The dielectric constant ($\varepsilon = 1.5 - 1.7$) is found from the observed degree of polarization. The best agreement with observation is obtained on the assumption that thermal lunar radiation suffers scattering, the effective scattering angle being about 40°.

A63-17314
EXPERIMENTAL TELEVISION PHOTOGRAPHS OF THE MOON IN THE SPECTRAL REGION 0.8-2.3 μ.
N. F. Kuprevich (Academy of Sciences, Astronomical Council, Moscow, USSR).
(Astronomicheskii Zhurnal, vol. 39, Nov.-Dec. 1962, p. 1136-1138.)
Soviet Astronomy, vol. 6, May-June 1963, p. 883-885. Translation.

Presentation of results of TV observations of the lunar surface in the spectral region $\lambda\lambda$ 8000-23000, at the Pulkovo Observatory. The IR photographs are compared to those in the visual region obtained previously by other investigators. It is found that in the IR region there is an increase in the contrast of the photographs with increasing wavelength. Details which usually are not visible on ordinary photographs are revealed. A hypothesis is made that the increase in contrast and the appearance of new details on the lunar image can be explained by a decrease of luminescence radiation in the IP region.

A63-17626
INTERPLANETARY CORRELATION OF GEOLOGIC TIME.
Eugene M. Shoemaker, Robert J. Hackman, and Richard E. Eggleton (U.S. Dept. of the Interior, Geological Survey, Menlo Park, Calif.)
(American Astronautical Society, Annual Meeting, 7th, Proceedings, Dallas, Tex., Jan. 16-18, 1961.)
IN: Advances in the Astronautical Sciences, vol. VIII. New York, Plenum Press, Inc., 1963, p. 70-89. 57 refs.
NASA-supported research.

Exploration of two independent methods for the interplanetary correlation of geologic time, based on the interaction of the solid material of the solar system by collision. First, if the frequency of meteoroid impact and its variation with time on different planets can be established, the age of rock bodies exposed on their surfaces can be estimated from the distribution of superimposed impact craters. With certain assumptions, this method can be applied at the present time to correlation between the Earth and the Moon, and should be applicable to Mars when high resolution photographs become available. A second potential method depends on the transport

debris from the Moon and other planets to the Earth, where the debris becomes incorporated in the terrestrial stratigraphic record. In order to complete the correlation it is essential to be able to identify the source of the debris. It is indicated that this will be possible only at an advanced stage of space exploration. The method of impact frequency is illustrated by evaluation of the age of the lunar maria.

A63-17658

EXPERIMENTS FOR THE UNMANNED SCIENTIFIC EXPLORATION OF THE MOON.

Newton W. Cunningham (NASA, Lunar and Planetary Programs, Washington, D. C.)

(American Astronautical Society, Annual Meeting, 7th, Proceedings, Dallas, Tex., Jan. 16-18, 1961.)

IN: Advances in the Astronautical Sciences, vol. VIII. New York, Plenum Press, Inc., 1963, p. 525-530.

Discussion of some of the experiments being considered for lunar rough- and soft-landing payloads, together with the type of information that would be most desirable from a lunar orbiter. A brief summary of the steps necessary in the development of instrumentation for unmanned geologic investigations is also presented.

A63-17660

RECENT CINEMATOGRAPHIC WORK IN LUNAR PHOTOGRAPHY FROM PIC-DU-MIDI.

Zdeněk Kopal (University of Manchester, Manchester, England).

(American Astronautical Society, Annual Meeting, 7th, Proceedings, Dallas, Tex., Jan. 16-18, 1961.)

IN: Advances in the Astronautical Sciences, vol. VIII. New York, Plenum Press, Inc., 1963, p. 537-548.

Contract Nos. AF 61(052)-168, AF 61(052)-380, and AF 61(052)-496.

Presentation of a method of obtaining high-resolution cinephotographs of the lunar surface. Also given are examples of the results obtained in order to determine lunar surface coordinates within errors of less than 1 km and lunar elevations within 10 in.

A63-17662

RADAR MEASUREMENTS OF THE LUNAR SURFACE.

G. H. Pettengill and J. C. Henry (Massachusetts Institute of Technology, Lincoln Lab., Lexington, Mass.)

(American Astronautical Society, Annual Meeting, 7th, Proceedings, Dallas, Tex., Jan. 16-18, 1961.)

IN: Advances in the Astronautical Sciences, vol. VIII. New York, Plenum Press, Inc., 1963, p. 564-570. 13 refs.

USAF-Army-Navy-supported research.

Presentation of the results of some recent measurements of the radio-echo power scattered by the lunar surface. The measurements are made at 440 Mc using a parabolic reflector 84 feet in diam. and a peak transmitted power of approximately 2.5 Mw. Subject to several assumptions, the measurements are shown to be consistent with a surface dielectric constant of 2.8, which corresponds approximately to the bulk value for sand. Additionally, it is deduced that only about 5% of the surface is rough to the scale of 68 cm. Measurements of the depolarization of the scattered energy offer verification of the surface properties.

A63-17834

AN ATTEMPT AT A PHOTOMETRIC STUDY OF THE NATURE OF DETAILS ON THE SURFACE OF THE REMOTE SIDE OF THE MOON.

A. V. Markov and D. E. Shchegolev.

(Iskusstvennye Sputniki Zemli, no. 9, 1961, p. 48.)

Planetary and Space Science, vol. 11, May 1963, p. 549-551. Translation.

Photometric study of pictures of the Moon's remote side. Photometric measurements are made diametrically transverse to the "intensity equator" in the direction of the television scanning lines and transverse to them. Within the limits of the photometry, it can be supposed that the remote side of the Moon is essentially the same as its near side with regard to the degree of erosion visible and the range of graduation of the reflectivity of its details.

A63-17901

LUNAR TOPOGRAPHY.

Ewen A. Whitaker (University of Arizona, Lunar and Planetary Lab., Tucson, Ariz.)

(American Astronautical Society, Symposium on Manned Lunar Flight; American Association for the Advancement of Science, Annual Meeting, 128th, Proceedings, Denver, Colo., Dec. 29, 1961.)

IN: Advances in the Astronautical Sciences. Vol. X - Manned Lunar Flight. North Hollywood, Calif., Western Periodicals Co., 1963, p. 237-250.

Review of the topographical features of the visible portion of the Moon. The many characteristics of the lunar surface are classified by type, and selected sections of the visible surface are illustrated. Photographs presented have been developed using advanced photographic techniques.

A63-17902

PRELIMINARY INVESTIGATION OF LUNAR SURFACE COMMUNICATIONS.

J. P. Ferrara and M. Chomet (Cutter-Hammer, Inc., Airborne Instruments Lab., Deer Park, N. Y.)

(American Astronautical Society, Symposium on Manned Lunar Flight; American Association for the Advancement of Science, Annual Meeting, 128th, Proceedings, Denver, Colo., Dec. 29, 1961.)

IN: Advances in the Astronautical Sciences. Vol. X - Manned Lunar Flight. North Hollywood, Calif., Western Periodicals Co., 1963, p. 251-264.

Presentation of the results of a preliminary study on the utilization of medium radio frequencies for beyond-line-of-sight transmission on the surface of the Moon. Ground-wave field intensity is calculated as a function of distance and frequency. The effects of cosmic noise, receiver parameters, and the field intensities are combined in a plot of maximum range vs frequency for a given transmitter power.

A63-17903

LUNAR BASING.

John DeNike (Martin-Marietta Corp., Space Systems Div., Baltimore, Md.)

(American Astronautical Society, Symposium on Manned Lunar Flight; American Association for the Advancement of Science, Annual Meeting, 128th, Proceedings, Denver, Colo., Dec. 29, 1961.)

IN: Advances in the Astronautical Sciences. Vol. X - Manned Lunar Flight. North Hollywood, Calif., Western Periodicals Co., 1963, p. 265-278.

Discussion of factors to be considered in planning permanent, manned bases on the Moon, with particular emphasis on shelter design and construction. Problems posed by lunar mission manning requirements and lunar environment are evaluated. Three basic types of shelter systems are discussed: above-ground, covered, and tunneled. It is concluded that, although additional information about the lunar environment is needed, enough data are available to begin the research and development phase of a permanent Moon base.

A63-17904

LUNAR EXPLORATION VEHICLES AND EQUIPMENT.

J. E. Froehlich and Allyn B. Hazard (Space General Corp., Glendale, Calif.)

(American Astronautical Society, Symposium on Manned Lunar Flight; American Association for the Advancement of Science, Annual Meeting, 128th, Proceedings, Denver, Colo., Dec. 29, 1961.)

IN: Advances in the Astronautical Sciences. Vol. X - Manned Lunar Flight. North Hollywood, Calif., Western Periodicals Co., 1963, p. 279-302.

Discussion of the design objectives and underlying assumptions for a functional manned lunar exploration vehicle. Possible means of locomotion are discussed, including the use of walkers, hoppers, and hover rockets. Probable types of prime movers, and equipment requirements for life support, communications, and surface navigation systems are discussed. Several likely moonmobile configurations are described.

A63-17970

THERMAL PROPERTIES OF A SIMULATED LUNAR MATERIAL IN AIR AND IN VACUUM.

E. C. Bernett, H. L. Wood, L. D. Jaffe, and H. E. Martens (California Institute of Technology, Jet Propulsion Laboratory, Pasadena, Calif.)
AIAA Journal, vol. 1, June 1963, p. 1402-1407. 12 refs.
Contract No. NAS 7-100.

Evaluation of the properties of a powdered rock simulating the postulated lunar surface material in order to measure the effects of vacuum on the thermal diffusivity and conductivity of rock powder. The thermal diffusivity and thermal conductivity for a crushed olivine basalt are determined from transient-state data. Values are obtained over a temperature range of -100° to 200°C in vacuums of 5×10^{-3} and 5×10^{-6} mm Hg. This is approximately 100 times lower than the values obtained for the same material measured at atmospheric pressure. Increasing the density to 1.57 g/cm^3 increases the thermal conductivity by approximately 60% in both air and vacuum. Over the range studied, the test temperature has very little effect on thermal conductivity in air but shows more of an effect when the material is placed in a vacuum.

A63-17987

FLOW FIELD OF AN EXHAUST PLUME IMPINGING ON A SIMULATED LUNAR SURFACE.
Donald W. Eastman and Leonard P. Radtke (Boeing Co., Aero-Space Div., Seattle, Wash.)
AIAA Journal, vol. 1, June 1963, p. 1430, 1431.

Presentation of a method for calculating the exhaust-plume flow field which is less restricted than the method presented by Roberts. Theoretical results are compared with experimental data, and also with Roberts' results. It is found that excellent agreement exists between theory and experiment, while Roberts' results are less valid for lower descent heights.

A63-18133

THE LUNAR SURFACE CONTROVERSY.
David Rostoker and John Lamb (Arthur D. Little, Inc., Cambridge, Mass.).
Industrial Research, vol. 5, May 1963, p. 23-27.

Review of the information and hypotheses advanced on the nature of the lunar surface. The controversy over whether or not the major features of the surface - the maria and craters - are of volcanic origin or from meteoric impact, is considered. The two major models proposed to describe the lunar surface are briefly analyzed. These are: (1) the surface consists of meteor slag; and (2) it is covered with a layer of fine dust. Methods of lunar mapping are outlined, and a typical section of such a map is presented. Information concerning the surface obtained from radar or echo studies, from thermal radiation measurements, and from illumination measurements, is discussed. The problems involved in man's adaptation to the lunar atmosphere are summarily considered.

A63-18188

NEW TYPE RADAR PROBING SURFACE OF MOON.
Philip J. Klass.
Aviation Week and Space Technology, vol. 78, May 6, 1963, p. 91.

Brief description of a high-resolution radar telescope being used to probe the lunar surface. The new equipment, operating at 8.6-mm wavelength and using a 28-ft-diam. precision antenna, achieves a beamwidth of only 4.3 min of arc, which corresponds to an area roughly 250 miles across on the lunar surface. First radar reflections from the lunar surface, obtained at a frequency of 35,000 Mc, indicate that the surface is fairly rough with respect to the dimensions of the waves employed.

A63-18371

THE MOON.
Edited by Zdeněk Kopal (University of Manchester, Manchester, England) and Zdenka Kadla Mikhailov (Main Astronomical Observatory, Pulkovo, USSR).
(International Astronomical Union, Symposium, 14th, Pulkovo, USSR, Dec. 1960.)
New York, Academic Press, Inc., 1962. 571 p.
$19.00.

Collection of papers dealing with lunar investigations, including theoretical and experimental studies, in the fields of (1) rocket exploration; (2) selenodesy and mapping of the Moon; (3) the origin, internal structure, and surface of the lunar globe; (4) physical studies of the lunar surface; and (5) radio observations of the Moon. Included is a foldout map covering a characteristic portion of the lunar surface to a scale of 1:1,000,000. Presented are accounts of Russian investigations, as well as others, in the field of lunar radioastronomy and of the far side of the Moon. An account of the gas outburst from the crater, Alphonsus, is also given. The papers are individually abstracted and indexed in this issue.

A63-18372

THE REVERSE SIDE OF THE MOON.
A. A. Mikhailov (Main Astronomical Observatory, Pulkovo, USSR).
(International Astronomical Union, Symposium, 14th, Pulkovo, USSR, Dec. 1960.)
IN: The Moon. New York, Academic Press, Inc., 1962, p. 3-6.

Brief consideration of the information gleaned concerning the reverse side of the Moon from the flight of Lunik 3 (1959 Theta). Briefly outlined is the type of equipment carried by the space vehicle, its method of photographing the lunar surface, and the means of transmitting the data to Earth. The best method for deciphering the pictures obtained consists of the preparation of several photometric cross sections from each frame for various density values. The method of compiling the "Atlas of the Far Side of the Moon" is noted. Considered are the major differences between the visible side and the far side of the Moon, including the scarcity of seas on the latter.

A63-18373

A STUDY OF PHOTOGRAPHS OF THE FAR SIDE OF THE MOON AND DESCRIPTION OF SINGULAR FEATURES REVEALED ON ITS SURFACE.
Y. N. Lipsky (Shternberg Astronomical Institute, Moscow, USSR).
(International Astronomical Union, Symposium, 14th, Pulkovo, USSR, Dec. 1960.)
IN: The Moon. New York, Academic Press, Inc., 1962, p. 7-23.

Consideration of the interpretation and designation of the features of the far side of the Moon as seen from photographs taken from Lunik 3 (1959 Theta). The conditions that had to be taken into account in selecting the initial moment of illumination (what region should be photographed and what should be the phase of the Moon in relation to the rocket) are discussed. Methods of detecting the features shown on the photographs are described, including simultaneous superposition of negatives, photographic masking, and photometric cross sections, which is found to be the most valuable. Photographs of photometric cross sections are presented and analyzed. The new formations found are divided into three categories according to their degree of authenticity. Considered are some of the primary features found, including the Mare Marginis, Australe, and Humboldtianum, and various crater formations. It is shown that the objects situated on the far side of the Moon do not differ in nature or structure from those on the visible side. The regions occupied by craters with a high reflectivity apparently occupy the major part of the surface. The presence of centers of ray systems and mountain formations is noted.

A63-18374

SCHEMATIC CHART OF THE FAR SIDE OF THE MOON.
I. I. Breido and D. E. Shchegolev (Main Astronomical Observatory, Pulkovo, USSR).
(International Astronomical Union, Symposium, 14th, Pulkovo, USSR, Dec. 1960.)
IN: The Moon. New York, Academic Press, Inc., 1962, p. 25-38.

Presentation of a schematic chart which shows the approximate distribution of the brightness of 107 features on the marginal visible side of the Moon, and on its far side, as detected by photographs taken by Lunik 3 (1959 Theta). Analysis of the photographs, and the methods employed for drawing up the chart, are outlined. On three preliminary charts are plotted only the features whose form and location coincided on not less than two photographic frames, and by

comparing these charts with each other, the schematic chart is constructed. Briefly discussed are the particularly striking features, such as the large crater Giordano Bruno and the Soviet Mountain range.

A63-18375

PROBABLE STRUCTURE AND NATURE OF THE FORMATIONS ON THE REVERSE SIDE OF THE MOON ACCORDING TO PHOTOMETRIC MEASUREMENTS OF LUNAR PHOTOGRAPHS.

A. V. Markov (Main Astronomical Observatory, Pulkovo, USSR).

(International Astronomical Union, Symposium, 14th, Pulkovo, USSR, Dec. 1960.)

IN: The Moon. New York, Academic Press, Inc., 1962, p. 39-44.

Brief consideration of the structure of the far side of the Moon as suggested by photographs taken by Lunik 3 (1959 Theta). Because the photographs are obtained without photometric calibration, they are calibrated by taking into account the brightness of ten details of the hemisphere of the Moon visible from the Earth. It is seen that the reverse side of the Moon, just like the visible side, at full phase, is characterized by no darkening toward the limb. Based on the determinations of the reflectivity of 16 objects, it is shown that the reverse side of the Moon has few seas, a large continental plateau with reflecting capacity similar to that on the visible side, and some radiation craters and radiation systems similar in albedo to the Tycho-Kepler systems.

A63-18377

DEFINITION OF THE CENTER OF THE MOON AND OF A REFERENCE SURFACE [DEFINITION DU CENTRE DE LA LUNE ET D'UNE SURFACE DE REFERENCE].

Th. Weimer (Observatoire de Paris, Meudon, Seine-et-Oise, France).

(International Astronomical Union, Symposium, 14th, Pulkovo, USSR, Dec. 1960.)

IN: The Moon. New York, Academic Press, Inc., 1962, p. 55-58. In French.

Outline of a method for finding the center of the Moon by superimposing surface profiles from various maps and taking the mean values of these profiles as the desired position. Representative profiles are presented, as is a sketch of the complete surface of the Moon found by this method. One interesting result is the existence of a permanent deformation at 14°. The surface thus determined is discussed in terms of the Yakovkin effect.

A63-18378

THE U.S. NAVAL OBSERVATORY SURVEY OF THE MARGINAL ZONE OF THE MOON.

C. B. Watts (U.S. Naval Observatory, Washington, D.C.).

(International Astronomical Union, Symposium, 14th, Pulkovo, USSR, Dec. 1960.)

IN: The Moon. New York, Academic Press, Inc., 1962, p. 59-61.

Brief outline of the methods used for drawing up charts of the lunar marginal zone, based on 700 photographs taken on 503 nights. The usual procedure of fitting a circular arc to each profile is followed to obtain a representation of the outline of a preliminary spherical datum surface. Measured elevations are scaled from the profiles for each 0.2° of position angle and adjusted to the scale of the Moon at mean distance. Each chart is intended to indicate the elevations to be found on the limb of the Moon at a designated position angle. Representative data are presented in a curve showing the normal apparent gradients to be found in position angle 159.6°.

A63-18379

A STUDY OF THE FIGURE OF THE MOON FROM PHOTOGRAPHS OF THE FULL MOON.

H. I. Potter (Main Astronomical Observatory, Pulkovo, USSR).

(International Astronomical Union, Symposium, 14th, Pulkovo, USSR, Dec. 1960.)

IN: The Moon. New York, Academic Press, Inc., 1962, p. 63-66.

Outline of a method for checking the available charts and models of the general figure of the Moon. The following method is adopted: through 180 points of the limb, the best-fit circle is drawn (i.e., its radius and the coordinates of the center are drawn). This is repeated for half of the lunar disk, rotated through 15°, until the entire circumference is covered. As a result, 24 systems of values are obtained for the radii and coordinates of the centers of the best-fit circles corresponding to different parts of the limb. If these or any other corrections accurately characterize the general figure of the Moon, then all the 24 values of x, y, r, should coincide with each other. The systems of 24 x, y, r values are obtained in five combinations: (1) without any corrections, (2) with corrections according to Yakovkin, (3) with corrections according to Nefedyev's charts, (4) with corrections according to Hayn's charts, and (5) with corrections corresponding only to the obtained elliptical model.

A63-18381

THE PRECISION OF THE DISTANCES OF A CRATER TO THE CENTER OF THE LUNAR GLOBE AS A FUNCTION OF THE PRECISION OF THE MEASUREMENTS [PRECISION DES DISTANCES "CRATERE-CENTRE GLOBE LUNAIRE" EN FONCTION DE LA PRECISION DES MESURES].

Th. Weimer (Observatoire de Paris, Meudon, Seine-et-Oise, France).

(International Astronomical Union, Symposium, 14th, Pulkovo, USSR, Dec. 1960.)

IN: The Moon. New York, Academic Press, Inc., 1962, p. 79-84. In French.

Presentation of a detailed table of the major craters, as measured on the plates of Markowitz, listing the names, coordinates, diameters, and brief remarks concerning the surface characteristics of each crater. In drawing the table it is assumed that the librations and necessary parameters are known without error. A formula is presented from which the definition of the distance of a crater from the center of the Moon is determined. The formula is discussed in terms of the error in experimental measurements.

A63-18382

LUNAR MULTIANGULAR STATISTICAL ADJUSTMENT (A GEOMETRICAL APPROACH TO LUNAR CONTROL).

Donald H. Eckhardt (Ohio State University, Columbus, Ohio) and Mahlon S. Hunt (USAF, Research Laboratories, Bedford, Mass.).

(International Astronomical Union, Symposium, 14th, Pulkovo, USSR, Dec. 1960.)

IN: The Moon. New York, Academic Press, Inc., 1962, p. 85-100.

Estimation of the relative locations of a number of control points on the surface of the Moon by geometric means, independent of physical lunar theory. Given a series of lunar photographic plates, taken at various librations, with the same lunar features such as bright spots or craterlets that are located on most plates, then, with certain assumptions, the method of maximum likelihood is applied to effect a multiangular adjustment. One major assumption is that there are no systematic errors in the projection of the Moon on the plates, or that such errors, if they exist, can be removed. For example, compensation may be made for differential astronomical refraction, but photographic errors such as irradiation and emulsion instability cannot be handled. Considered are some of the problem areas which may result if the presently available lunar source materials are used to try to perform first-order selenodetic investigations, including craterlets vs bright spots, random errors, and systematic errors.

A63-18383

ON THE PROBLEMS OF SELENODETIC PHOTOGRAMMETRY.

D. W. G. Arthur (University of Arizona, Lunar and Planetary Laboratory, Tucson, Ariz.).

(International Astronomical Union, Symposium, 14th, Pulkovo, USSR, Dec. 1960.)

IN: The Moon. New York, Academic Press, Inc., 1962, p. 101-106.

Brief consideration of the two major selenodetic problems. Discussion of the determination of the geometrical figure of the Moon outlines an analytical formulation for the coordination of the lunar surface from the photographic measurements alone, in terms of 3-vectors and dyadics. The case which is similar to Fourcade's correspondence theorem is briefly considered. It is pointed out that the lunar photograph is virtually an orthographic projection,

and it is shown that the solution for two plates is indeterminate for orthographic pictures. Discussion of the second selenodetic problem, that of the determination of the rotation constants of the Moon, outlines two possible approaches for stating the observation equations in terms of the rectangular coordinates of the points in the plane of the image, without reference to the limb, or at least in such manner that the limb plays a purely secondary role.

A63-18384

DETERMINATION OF HORIZONTAL AND VERTICAL CONTROL POINTS FOR LUNAR MAPPING.

Marvin Q. Marchant (U.S. Army, Corps of Engineers, Washington, D.C.).

(International Astronomical Union, Symposium, 14th, Pulkovo, USSR, Dec. 1960.)

IN: The Moon. New York, Academic Press, Inc., 1962, p. 107-111.

Brief consideration of methods for determining the horizontal and vertical control points for lunar mapping, in order to assure that the entire surface which is visible from the Earth may be shown in detail and with greater accuracy than that of any existing maps. Recently available lunar photography and standard stereo-photogram metric equipment is used in performing tests made with photographs of spheres scaled to the base-height ratio of the lunar photographs. Tests indicate that the lunar surface can be adequately controlled by having a distribution of control points over the surface such that there is at least one control point per sector having an area equal to that of a $10^{\circ} \times 10^{\circ}$ square of the equator of the Moon. A modified stereographic projection of that portion of the Moon which is visible from the surface of the Earth is presented, and its mapping discussed.

A63-18385

A PHOTOGRAPHIC MAP OF THE MOON.

D. W. G. Arthur and E. A. Whitaker (University of Arizona, Lunar and Planetary Laboratory, Tucson, Ariz.).

(International Astronomical Union, Symposium, 14th, Pulkovo, USSR, Dec. 1960.)

IN: The Moon. New York, Academic Press, Inc., 1962, p. 113-115.

Brief description of the method used in the production of an atlas of large-scale lunar photographs carrying the standard orthographic map grid at intervals of 0.1 of the lunar radius. The grid is based on the position catalogs of Franz and Saunder, and also on some unpublished lists by Arthur.

A63-18386

LUNAR CHARTING ON THE SCALE 1:1,000,000.

Robert W. Carder (USAF, Aeronautical Chart and Information Center, St. Louis, Mo.).

(International Astronomical Union, Symposium, 14th, Pulkovo, USSR, Dec. 1960.)

IN: The Moon. New York, Academic Press, Inc., 1962, p. 117-129.

Description of the production of a 1:1,000,000 scale chart on the Moon, called the Kepler Chart. Briefly reviewed is some of the lunar cartographic history. The entire chart measures 56 x 73 cm, with 1 cm representing about 10 km on the Moon. A significant aspect of the chart is the fact that it establishes 300-m contours on the lunar surface. Surface features are shown by a combination of shaded relief, contours, and tones representing surface color variations. The instrument, identified as the Variable Perspective Projector, adopted for rectification of lunar photographs, is briefly described. Methods of determining elevations and basic horizontal control are outlined. Single microdensitometer tracings are used when the objective is to find the height of a peak or the depth of a small crater on the lunar surface.

A63-18387

THE ORIGIN OF THE MOON AND ITS RELATIONSHIP TO THE ORIGIN OF THE SOLAR SYSTEM.

Harold C. Urey (University of California at San Diego, La Jolla, Calif.).

(International Astronomical Union, Symposium, 14th, Pulkovo, USSR, Dec. 1960.)

IN: The Moon. New York, Academic Press, Inc., 1962, p. 133-148. 26 refs.

Presentation of arguments concerning the structure of meteorites, the varying densities of the planets, the origin of the Moon, and radioactive heating of the meteorites by short-lived radioactive nuclides. Briefly considered is the duration of the intense lunar bombardment and the capture fuel composition of the Moon. Discussed in detail is the development of a flat nebula composed of solar proportions of the elements, assuming that the solids do not modify seriously the behavior of the gases, which are mostly molecular hydrogen and helium in the ratio of 4 to 1. Such a nebula would be subjected to forces from the Sun and its own gravitational field. If both these fields are included, complicated solutions are secured. Using the massive nebula postulated, the solar field is neglected. Evidence suggests that the Moon has a composition differing in iron content from the compositions of the terrestrial planets, and very similar to that of the nonvolatile fraction of the Sun.

A63-18390

THE GEOSCIENCES APPLIED TO LUNAR EXPLORATION.

J. Green (North American Aviation, Inc., Space and Information Systems Division, Space Sciences Laboratory, Downey, Calif.).

(International Astronomical Union, Symposium, 14th, Pulkovo, USSR, Dec. 1960.)

IN: The Moon. New York, Academic Press, Inc., 1962, p. 169-257. 126 refs.

Detailed discussion of the application of geosciences to manned lunar exploration, in terms of terrain, rocks, minerals, power, and tools. It is seen that, by understanding the processes which formed certain features on Earth, the advantages of impacted and volcanic terrains on the Moon can be realized. A lunar terrain would offer more natural protection to man. Volcanic rocks would also be more useful to the lunar astronaut than meteoritic rock because of the adaptability of certain volcanic materials for insulation, and because their water content is much higher.

A63-18391

ON MOON VOLCANISM.

N. Bonev (University of Sofia, Astronomical Institute, Sofia, Bulgaria).

(International Astronomical Union, Symposium, 14th, Pulkovo, USSR, Dec. 1960.)

IN: The Moon. New York, Academic Press, Inc., 1962, p. 259-262.

Brief consideration of the fact that the distribution of the craters over the eastern and the western halves of the Moon does not support the meteoritic hypothesis of the origin of the lunar craters. Reviewed is an investigation of the visible craters which showed that there are more craters on the first quarter than on the last quarter. An alternate hypothesis to explain the origin of the craters is considered, which involves the internal force of planetary bodies.

A63-18392

SPECTROSCOPIC PROOFS FOR EXISTENCE OF VOLCANIC PROCESSES ON THE MOON.

N. A. Kozyrev (Main Astronomical Observatory, Pulkovo, USSR).

(International Astronomical Union, Symposium, 14th, Pulkovo, USSR, Dec. 1960.)

IN: The Moon. New York, Academic Press, Inc., 1962, p. 263-271.

Consideration of the results of spectral investigations of the lunar surface, emphasizing that of the crater Alphonsus. Data of emission spectra presented show that the gases present consist of complex molecules, producing a weak emission, which escaped from the central peak of Alphonsus. It is conjectured that the central peaks of lunar craters may be of an origin similar to that of the cones of terrestrial volcanoes and, consequently, are gradually accumulated formations. The outer craters themselves may be similar to calderas of terrestrial volcanoes, formed by subsidence due to the depletion of magnatic seat. The observations reveal that the Moon has an internal energy sufficient for mountain-forming processes.

A63-18393
MICROPHOTOMETRIC ANALYSIS OF THE EMISSION FLARE IN THE REGION OF THE CENTRAL PEAK OF THE CRATER ALPHONSUS ON 3 NOVEMBER 1958.
A. A. Kaliniak and L. A. Kamionko (Main Astronomical Observatory, Pulkovo, USSR).
(International Astronomical Union, Symposium, 14th, Pulkovo, USSR, Dec. 1960.)
IN: The Moon. New York, Academic Press, Inc., 1962, p. 273-287

Microphotometric analysis of the spectrum obtained by Kozyrev and Ezersky of the central peak of the crater Alphonsus. It is shown that (1) the emission is produced by a fluorescent gas under the action of solar radiation; (2) there is a number of secondary maxima on the intensity distribution curve agreeing well in position with the molecular bands of the Swan system; (3) the absence of the resonance emission band (0-0) and the uncertain appearance of the band (1-0) can be explained by the presence of the bright background of the surface of the Moon, and the relatively low value of the kinetic temperature of the plasma in which the observed phenomenon occured; and (4) there is no evidence of thermal emission in the flare spectrum of the central peak.

A63-18394
STRATIGRAPHIC BASIS FOR A LUNAR TIME SCALE.
Eugene M. Shoemaker and Robert J. Hackman (U.S. Geological Survey, Menlo Park, Calif., and Washington, D.C.).
(International Astronomical Union, Symposium, 14th, Pulkovo, USSR, Dec. 1960.)
IN: The Moon. New York, Academic Press, Inc., 1962, p. 289-300. 12,refs.
NASA-supported research.

Brief description of the stratigraphic relations and surface characteristics of the overlapping series of deposits surrounding the major lunar craters, in order to outline the broad framework of a lunar time scale. A region around the crater Copernicus is selected for initial investigation, because it is favorably located near the center of the lunar disk, and is one where the relative succession of many stratigraphic units can be worked out. The materials described are grouped into five stratigraphic subdivisions, which, from oldest to youngest, are (1) pre-Imbrian material, (2) the Imbrian system, (3) the Procellarian system, (4) the Eratosthenian system, and (5) the Copernican system. Presented are a map showing the physiographic divisions of the Moon and a generalized photogeological map of the Moon.

A63-18395
PHOTOGEOLOGIC STUDY OF THE MOON.
Arnold C. Mason and Robert J. Hackman (U.S. Geological Survey, Washington, D.C.).
(International Astronomical Union, Symposium, 14th, Pulkovo, USSR, Dec. 1960.)
IN: The Moon. New York, Academic Press, Inc., 1962, p. 301-315.

Presentation of the most probable interpretations of the areas shown on a generalized photogeologic map of the Moon and a map showing the physical divisions of the Moon, which were compiled using a photomosaic in orthographic projection at an approximate scale of 1:3,800,000, prior to completion of the lunar topographic map. Outlined are (1) the lunar highlands, including the Imbrium-Serenitatis mountains and the Central and Southern, the Crisium-Fecunditatis, and the Northern Highlands; and (2) the lunar lowlands, including the Midlunar, the Northern, the Australe, and the Aestatis Lowlands. The study is seen to lend support to the suggestion that most visible craters on the Moon are the result of meteoric impact, although some craters and other features are interpreted as volcanic in origin, and are so distinguished where possible on the photogeologic map.

A63-18396
SOME SYSTEMATIC VISUAL LUNAR OBSERVATIONS.
D. W. G. Arthur (University of Arizona, Lunar and Planetary Laboratory, Tucson, Ariz.).
(International Astronomical Union, Symposium, 14th, Pulkovo, USSR, Dec. 1960.)
IN: The Moon. New York, Academic Press, Inc., 1962, p. 317-324.

Brief review of the features observed on the Moon by cartographic and topographic studies in order to supplement the defective resolving power of available photographs. The observer starts with the photograph as a base, adds details which are missing, and sharpens up those details which are hazy or doubtful in the photographic image. Outlined are the results of observations of craters, rilles, faults, domes, and mare ridges.

A63-18397
HIGH-RESOLUTION PHOTOGRAPHS OF SOME LUNAR AREAS [PHOTOGRAPHIES A GRANDE RESOLUTION DE CERTAINES REGIONS LUNAIRES].
Audouin Dollfus (Observatoire de Paris, Section d'Astrophysique, Meudon, Seine-et-Oise, France).
(International Astronomical Union, Symposium, 14th, Pulkovo, USSR, Dec. 1960.)
IN: The Moon. New York, Academic Press, Inc., 1962, p. 325-342. In French.

Presentation of photographs of different lunar formations including Aristillus, Inghirami, the region surrounding Maurolycus, Ptolemaeus, Grimaldi, Fracastorius, Wargentin, Triesnecker, Hyginus, Byrgius, and Alphonsus. The photographs have been made from 1944 to the present, and are described in terms of the improvement of photographic techniques and of the refinements in theories concerning the formations as the techniques were improved.

A63-18398
CINE PHOTOGRAPHY OF THE MOON FROM PIC-DU-MIDI.
Zdeněk Kopal and Thomas W. Rackham (University of Manchester, Dept. of Astonomy, Manchester, England).
(International Astronomical Union, Symposium, 14th, Pulkovo, USSR, Dec. 1960.)
IN: The Moon. New York, Academic Press, Inc., 1962, p. 343-360. Contract Nos. AF 61(052)-168, AF 61(052)-380, and AF 61(052)-496.

Discussion of the current photographic instrumentation and investigations of the Moon at the French high-altitude observatory at Pic-du-Midi. The purpose of the investigations is to get adequate data for extensive three-dimensional topographic evaluations of the lunar surface. Described in some detail are the telescopes and cameras which are used in the cinematographic studies of the sunrise and sunset phenomena on the surface of the Moon. From these studies it is possible to obtain the data for the accurate determination of the three-dimensional lunar coordinates. Typical photographs, taken with various cameras, are presented and analyzed.

A63-18399
TELEVISION ASTRONOMICAL OBSERVATIONS AT THE PULKOVO OBSERVATORY.
N. F. Kuprevich (Main Astronomical Observatory, Pulkovo, USSR).
(International Astronomical Union, Symposium, 14th, Pulkovo, USSR, Dec. 1960.)
IN: The Moon. New York, Academic Press, Inc., 1962, p. 361-368.

Consideration of the application of an experimental TV telescope to astronomical studies. The telescope is described, and its connection to the TV camera is outlined. The discussion covers the use of the telescope for taking experimental photographs of the Moon, for studying the changes in the form of a stellar image resulting from atmospheric disturbances and the deformation of star images at large magnifications, and for the simultaneous recording of the form of the light flux and that of the stellar image during scintillation. Modifications of the original TV telescope as a result of such investigations are briefly described, and the preliminary results of the studies are presented.

A63-18400
PHYSICAL NATURE OF DIFFERENT ZONES OF THE LUNAR SURFACE.
A. V. Markov (Main Astronomical Observatory, Pulkovo, USSR).
(International Astronomical Union, Symposium. 14th, Pulkovo,

USSR, Dec. 1960.)
IN: The Moon. New York, Academic Press, Inc., 1962, p. 371-378. 11 refs.

Critical examination of the information and hypotheses concerning the nature of the upper layer of the lunar crust. It is shown that Gold's hypothesis of the presence on the Moon of layers of dust with a depth up to tens of meters is incorrect. The great variations of temperature on the surface of the Moon at the time of eclipses and at different phases, as well as the confirmed presence of some kinds of volcanic action in individual regions, point to the conclusion that, in a number of regions subjected to such changes, small cracks up to 1 m wide may be found. In remaining regions of the Moon, and especially the zones of its surface investigated by polarization and thermoelectric measurements, the negative polarization and low thermal conductivity of the surface lead to the assumption that the surface is covered with fine-grain material to a depth of not less than 4 cm. It is shown that, if the meteor-slag hypothesis is valid, the outer layer of lunar rocks is harder than a powder layer.

A63-18401

THE ROCKS THAT MAY CONSTITUTE THE LUNAR SURFACE.
N. P. Barabashev (Kharkov Astronomical Observatory, Kharkov, USSR).
(International Astronomical Union, Symposium, 14th, Pulkovo, USSR, Dec. 1960.)
IN: The Moon. New York, Academic Press, Inc., 1962, p. 379-384.

Investigation of the nature of the lunar surface, based on the statistical comparison of measurements on specimens of terrestrial rock with lunar photometric data. The study is in terms of such characteristics and parameters as brightness and smoothness factors; spectral distribution of reflectivity; degree of polarization, depending on angle of incidence, reflection, and phase in the different spectral regions; heat conductivity; and luminescence. It is shown that the surface of the Moon is covered, in all probability, by tuff-like rocks in a broken-up state, with the grains ranging in size from 3 to 10 mm. According to the character of light reflection, surfaces covered by sharp-edged fragments and rectilinear grooves with vertical and tapered walls correspond best to the lunar surface.

A63-18403

METEOR-SLAG THEORY OF THE LUNAR SURFACE.
N. N. Sytinskaia (Leningrad State University, Leningrad, USSR).
(International Astronomical Union, Symposium, 14th, Pulkovo, USSR, Dec. 1960.)
IN: The Moon. New York, Academic Press, Inc., 1962, p. 391-394 10 refs.

Brief consideration of how the meteor-slag theory of the origin of the lunar surface layer accounts for observed data. Listed are the major results of investigations of the properties of the lunar surface layer, based on measurements of the albedo, color, and changes in brightness with directions of incident and reflected rays, and thermoelectric observations of the thermal radiation of the Moon during lunar eclipses and during an average monthly cycle. The meteor-slag theory is based on the assumption that a sufficiently large part of the evaporating material condenses and precipitates near the place of explosion, forming a crust which consists of vesicular mass, with cavities separated by very thin walls. The manner in which the theory explains the low lunar reflectivity is outlined.

A63-18404

ON THE PHOTOMETRIC HOMOGENEITY OF THE LUNAR SURFACE.
N. P. Barabashev and V. I. Ezerskii (Kharkov Astronomical Observatory, Kharkov, USSR).
(International Astronomical Union, Symposium, 14th, Pulkovo, USSR, Dec. 1960.)
IN: The Moon. New York, Academic Press, Inc., 1962, p. 395-398.

Brief consideration of the results of paired comparisons of brightness in lunar areas which could be considered as interchangeable, based on values obtained from the photometric catalog of Fedorets. On the basis of the data, indicatrices of reflection of different details of the lunar surface are constructed, and comparisons are made in those cases where necessary conditions are fulfilled. It is found that the photometric homogeneity of the lunar surface shows the important role of external, cosmic factors exerting isotropic action on the formation of the microrelief of the lunar surface.

A63-18405

COLOUR AND SPECTRAL CHARACTERISTICS OF THE LUNAR SURFACE.
V. G. Teyfel (Kazakhstan Academy of Sciences, Astrophysical Institute, Alma-Ata, Kazakh SSR).
(International Astronomical Union, Symposium, 14th, Pulkovo, USSR, Dec. 1960.)
IN: The Moon. New York, Academic Press, Inc., 1962, p. 399-407. 10 refs.

Brief review of spectropolarimetric investigations of 19 objects in three regions of the Moon. Spectra of lunar regions are photographed near the quadratures in three positions of a polyvinyl polaroid placed in front of the slit of the spectrograph. The spectrograms show that the variation of polarization with wavelength is insignificant and decreases toward the red. The spectral curves of the lunar features show a monotonous variation of intensity with wavelength; therefore, the spectral differences in the visible spectral region are defined uniquely by the color index. The most interesting result of the investigation is found to be the relationship between the color and the relative brightness of lunar features.

A63-18406

THE COLOUR OF THE BRIGHT RAYS ON THE MOON.
L. N. Radlova (Institute of Scientific Information, Moscow, USSR).
(International Astronomical Union, Symposium, 14th, Pulkovo, USSR, Dec. 1960.)
IN: The Moon. New York, Academic Press, Inc., 1962, p. 409, 410.

Brief review of visual and phographic measurements of the color of several rays on the surface of the Moon. It is found that such measurements confirm the subjective impression that the rays differ from the background only in brightness, but not in color. Taking into account the fact that rays and rings also differ only slightly from the background by their albedo and the law of light reflection, it is considered probable that the surface of the rays consists basically of the same materials as the surface of the continents. In the former, however, these materials are somewhat more finely pulverized.

A63-18407

A STUDY OF THE ANGLE OF REPOSE OF SOME LOOSE MATERIALS AND ITS BEARING ON THE HYPOTHESIS OF A DUST LAYER ON THE LUNAR SURFACE.
N. S. Orlova (Leningrad State University, Astronomical Observatory, Leningrad, USSR).
(International Astronomical Union, Symposium, 14th, Pulkovo, USSR, Dec. 1960.)
IN: The Moon. New York, Academic Press, Inc., 1962, p. 411-414.

Experimental determination of the angle of repose of loose material including sand, dust, and volcanic ash, using a medium-sized telescope provided with an ocular micrometer, the wires of which are set parallel to the slopes of the cone. The angles of repose of volcanic cones of piled-up loose material are obtained from photographs published in special issues and from photographic atlases of volcanoes of different countries. In order to study the photometric relief of a rough surface with the maximum angles of repose of 45°, models are specially prepared in the laboratory and investigated. The first model consists of a surface completely covered by four-sided pyramids; and the second, by three-sided pyramids.

A63-18408

FORMATION OF LUNAR CRATERS AND BRIGHT RAYS AS A RESULT OF METEORITE IMPACTS.
K. P. Staniukovich and V. A. Bronshten (All-Union Astronomical and Geodetic Society, Moscow, USSR).
(International Astronomical Union, Symposium, 14th, Pulkovo,

USSR, Dec. 1960.)
IN: The Moon. New York, Academic Press, Inc., 1962, p. 415-418. 14 refs.

Brief review of studies of the phenomena accompanying the impact of large meteorites on the lunar or terrestrial surfaces, examined on the basis of the theory of explosive phenomena. As an example, a crater produced by an explosion of a charge buried at a depth of 30 m below the ground, which is carried out for the purpose of seismographic investigations, is briefly considered. Experiments simulating the kinetic impact described by Charters are reviewed, as are the experiments in simulation of lunar craters conducted by Benevolensky. The various opinions concerning the mechanism of formation of crater walls are discussed.

A63-18409
SOME RESULTS DEDUCED FROM SIMULATION OF LUNAR CRATERS.
P. F. Sabaneev (Rostov University, Rostov, USSR).
(International Astronomical Union, Symposium, 14th, Pulkovo, USSR, Dec. 1960.)
IN: The Moon. New York, Academic Press, Inc., 1962, p. 419-431.

Simulation experiments conducted by dropping a lump of a loose substance on a layer of some loose materials placed on a level and firm base, in order to investigate lunar crater formation. Outlined is the effect on the model of increasing the weight of dropped material, as well as the influence of such factors as the physical properties of impinging matter (its form, angle of incidence, velocity, and size), the atmospheric medium, and the magnitude of gravity, and also the mechanical properties of the soil and its stratigraphic structure. On the basis of the experiments it is concluded that (1) craters and maria with clearly defined perimeters emerge as a result of the infall of dense, homogeneous, and definitely circular masses of loose matter; (2) an appreciable number of small craters may have emerged as secondary formations; (3) the surface of the Moon is covered with matter consisting of hard rock with a lower firmness than the deeper layers; and (4) the formation of craters is accompanied by the ejection of fragments of surface rocks into interplanetary space.

A63-18410
PROCESSES ON THE LUNAR SURFACE.
T. Gold (Cornell University, Ithaca, N.Y.).
(International Astronomical Union, Symposium, 14th, Pulkovo, USSR, Dec. 1960.)
IN: The Moon. New York, Academic Press, Inc., 1962, p. 433-439. General Motors Corp.-supported research.

Consideration of possible mechanisms of transportation of material over the lunar surface, in order to rationalize the fact that the infalling material adds more than it evaporates. It is suggested that material may constantly be removed from the high ground, presumably in finely powdered from, and then migrate to the low ground. It is seen that electrostatics seems to offer the best explanation of material transportation. Two such processes are analyzed: (1) "electrostatic hopping" caused when two neighboring particles acquire a large charge of similar sign in the course of erratic charge distributions; and (2) "gliding" which occurs because the constant emission of electrons from the surface of the Moon produces a distribution of potential of several volts (positive), surrounded by a space-charge of electrons mostly in transit between emission and return to the lunar surface. Thermal data now available from radio thermal measurements are discussed in relation to the dust hypothesis of the lunar surface.

A63-18413
INVESTIGATION OF THE POLARIZATION PROPERTIES OF THE SURFACE OF THE MOON.
E. K. Kohan (Main Astronomical Observatory, Pulkovo, USSR).
(International Astronomical Union, Symposium, 14th, Pulkovo, USSR, Dec. 1960.)
IN: The Moon. New York, Academic Press, Inc., 1962, p. 453-461. 19 refs.

Presentation of the results of an investigation of polarization characteristics of lunar surface formations and numerous ground rocks in accordance with the two Stokes parameters, the degree of polarization and the orientation angle of the polarization plane of reflected light. Thirty-five regions on the surface of the Moon are selected, representing various types of formations, including the conventional maria, crater-type maria, craters with central peaks, bays, and regions on the continent. The results are discussed in terms of the factors influencing the orientation angle of the polarization plane on the Moon for a given phase, for the different types of formations.

A63-18414
FIRST RESULTS FROM OBSERVATIONS OF THE MOON BY MEANS OF A POLARIMETER.
V. P. Dzhaparidzeh and L. V. Ksanfomaliti (Georgian Academy of Sciences, Abastumani Astrophysical Observatory, Abastumani, USSR).
(International Astronomical Union, Symposium, 14th, Pulkovo, USSR, Dec. 1960.)
IN: The Moon. New York, Academic Press, Inc., 1962, p. 463-467.

Brief discussion of observations made with an automatic electronic polarimeter which provides direct measurement of the degree of light polarization and of the angle determining the position of the polarization plane. The instrument is analogous to an electronic computer solving the equation $P = x - y / x + y$. An experimental program of stellar, lunar, and planetary observations is outlined, in which the instrument is used as a photometer as well as a polarimeter. It is found that the instrument offers a means of obtaining a complete polarization chart of the Moon by the method of interlinear resolution.

A63-18415
ECLIPSE TEMPERATURES OF THE LUNAR CRATER TYCHO.
William M. Sinton (Lowell Observatory, Flagstaff, Ariz.).
(International Astronomical Union, Symposium, 14th, Pulkovo, USSR, Dec. 1960.)
IN: The Moon. New York, Academic Press, Inc., 1962, p. 469-471.

Brief summary of temperature observations of Tycho during a total eclipse, made with a 1.5-μ bandwidth at 8.8μ, the calibration being made by direct comparison with blackbodies of known temperature. Two scans across Tycho are presented which illustrate the rapid temperature decay of most of the lunar surface and the relative constancy of temperatures of Tycho during the eclipse. A graph shows the temperatures of Tycho and its environs, and comparisons with theoretical curves corresponding to different models.

A63-18416
RADIO EMISSION OF THE MOON, ITS PHYSICAL STATE, AND THE NATURE OF ITS SURFACE.
V. S. Troitskii (Gor'kii State University, Institute of Radiophysics, Gor'kii, USSR).
(International Astronomical Union, Symposium, 14th, Pulkovo, USSR, Dec. 1960.)
IN: The Moon. New York, Academic Press, Inc., 1962, p. 475-489. 32 refs.

Summary of the results of measurements of the radio emission of the Moon in widely spaced wavelengths ranging from 0.4 to 3.2 cm. The measurements indicate a quasi-homogeneous structure of the surface layer of the Moon. Briefly considered are the results of theoretical and experimental investigations of lunar radio emission. Basic conclusions from the experimental data on the nature and physical state of the surface layer are outlined. The single-layer model of the lunar surface is considered in terms of a comparison of the electrical parameters of the lunar and terrestrial material, and the density and dielectric constant of lunar material is compared with those of terrestrial rocks. Also considered are the heat conductivity and depth of penetration of the thermal and electromagnetic waves into the lunar surface. The true temperature of the lunar surface is calculated as a minimum of 127° and a maximum of 407°K.

A63-18417

THERMAL RADIO EMISSION OF THE MOON AND CERTAIN CHARACTERISTICS OF ITS SURFACE LAYER.

A. E. Salomonovich (Lebedev Physics Institute, Moscow, USSR).

(International Astronomical Union, Symposium, 14th, Pulkovo, USSR, Dec. 1960.)

IN: The Moon. New York, Academic Press, Inc., 1962, p. 491-495. 14 refs.

Discussion of the results of observations of the Moon with a 22-m radio telescope which allow an evaluation of certain characteristics of the surface layer without relying entirely on optical data. The brightness temperature, within the accuracy of relative errors of measurement (±2%), is found to be independent of the phase of the Moon and equal to 230°K. Examples of the distribution obtained at wavelengths of 0.8 and 3.2 cm are presented. The region of maximum radio brightness shifts systematically along the lunar equator following the subsolar point. A table lists the ratios of the periodic brightness-temperature variations in the center of the disk to the mean values, as well as the ratios of the depth of penetration of radio and the first harmonic of the thermal wave. These parameters are discussed, and their values compared with those obtained by Jaeger. It is seen that the data give more definite evidence in favor of the one-layer model of the lunar surface.

A63-18420

THE RADIO EMISSION OF THE MOON ON 4 mm.

A. G. Kisliakov (Gor'kii State University, Institute of Radiophysics, Gor'kii, USSR).

(International Astronomical Union, Symposium, 14th, Pulkovo, USSR, Dec. 1960.)

IN: The Moon. New York, Academic Press, Inc., 1962, p. 511-518. 20 refs.

Experimental investigation of the intensity of the radio emission of the Moon at 4 mm. The methods employed in the observation and data reduction are described. It is established that the variation of radio brightness of the Moon during lunation is expressed by the law: $T_l = 230^\circ + 73^\circ \cos(\Omega_0 t - 24^\circ)$K, where $\Omega_0 t$ represents the optical phase of the Moon. Comparison of the phase dependence of the radio emission at 4 mm with the data from observations of the radio temperature of the lunar disk on other wavelengths demonstrates that the homogeneous model of the lunar surface is in good agreement with the experimental data.

A63-18421

RADAR MEASUREMENTS OF THE LUNAR SURFACE.

G. H. Pettengill and J. C. Henry (Massachusetts Institute of Technology, Lincoln Laboratory, Cambridge, Mass.).

(International Astronomical Union, Symposium, 14th, Pulkovo, USSR, Dec. 1960.)

IN: The Moon. New York, Academic Press, Inc., 1962, p. 519-525. 13 refs.

Presentation of the results of measurements of the radio echo-power scattered by the lunar surface, made at a RF of 440 Mc, using a parabolic reflector of 84-ft diameter and a peak transmitted power of approximately 2.5 Mw. Shown graphically, and discussed briefly in terms of theoretical interpretations, are (1) the received power vs delay for signals received from the Moon, (2) the received power vs angle of incidence with respect to the lunar surface, (3) lunar echo power vs delay for two orthogonal received polarizations, and (4) polarization vs delay for lunar echoes.

A63-18422

OBSERVATIONS OF RADIO EMISSION OF THE MOON AT 2.3 cm WITH THE PULKOVO LARGE RADIO TELESCOPE.

N. L. Kaydanovsky, V. N. Ihsanova, G. P. Apushkinsky, and O. N. Shivris (Main Astronomical Observatory, Pulkovo, USSR).

(International Astronomical Union, Symposium, 14th, Pulkovo, USSR, Dec. 1960.)

IN: The Moon. New York, Academic Press, Inc., 1962, p. 527-532.

Presentation of the results of radio observations of the Moon made at a wavelength of 2.3 cm, in order to determine the displacement of the center of gravity of lunar radio emission as a function of phase. Methods of determining the brightness temperature variation at the center of the lunar disk from the measurement of the displacement of the center of gravity are outlined. Using such a relation, the temperature variation is found to be 13.5 ± 4°K.

A63-18423

SOME PHYSICAL CONSTANTS OF THE LUNAR SURFACE AS INDICATED BY ITS RADAR SCATTERING AND THERMAL EMISSION PROPERTIES.

T. B. A. Senior, K. M. Siegel and A. Giraud (University of Michigan, Radiation Laboratory, Ann Arbor, Mich.).

(International Astronomical Union, Symposium, 14th, Pulkovo, USSR, Dec. 1960.)

IN: The Moon. New York, Academic Press, Inc., 1962, p. 533-543.

NASA-Army-supported research; Grant No. NsG-4-59.

Summary of the results of lunar studies, emphasizing the analysis of radar-scattering and thermal-emission data. The scattering of radar signals by the Moon is described, and a theory to account for the observed features in terms of a scattering process closely akin to that of a smooth body, first proposed by Senior and Siegel, is presented. It is shown that, as a consequence of this theory, it is possible to determine the electromagnetic parameters of certain portions of the lunar surface; in particular, it is found that the relative permittivity (or dielectric constant) is about 1.1. Thermal radio emission from the Moon is described, and, by using the electromagnetic parameters obtained, the thermal parameters of the lunar surface are deduced from an analysis of the thermal emission. It is seen that the parameters are compatible with the character of the lunar surface as suggested by the radar data.

A63-18424

THE ELECTROMAGNETIC PARAMETERS OF SELECTED TERRESTRIAL AND EXTRATERRESTRIAL ROCKS AND GLASSES.

W. E. Fensler, E. F. Knott, A. Olte, and K. M. Siegel (University of Michigan, Radiation Laboratory, Ann Arbor, Mich.).

(International Astronomical Union, Symposium, 14th, Pulkovo, USSR, Dec. 1960.)

IN: The Moon. New York, Academic Press, Inc., 1962, p. 545-565. 11 refs.

NASA-Army supported research; Grant No. NsG-4-59.

Experimental investigation of the physical properties of the surface layer of the Moon as simulated by terrestrial materials. Measurements of the electromagnetic constants of solids of reasonable volumes are made. These solids are broken up into smaller and smaller pieces, and the average permittivities of each mixture are measured. The basic idea is to determine how closely the electromagnetic constants of these materials, and their form, approach those predicted from the electromagnetic measurements of the Moon. It is found that the meteorites, tektites, glasses, and rocks as found on Earth do not have the same electromagnetic properties as the materials on the surface of the Moon. It is seen that by crushing materials to obtain particle sizes in the regions indicated by optical, IR, and passive microwave data, the constants approach those values obtained by electromagnetic diagnostics of the lunar surface.

A63-18425

CHARACTERISTICS OF PARTICLES BLOWN AWAY BY EXHAUST JET IMPINGEMENT ON A LUNAR SURFACE.

Robert L. Grossman (Grumman Aircraft Engineering Corp., Propulsion Section, Bethpage, N.Y.).

American Institute of Aeronautics and Astronautics, Summer Meeting, Los Angeles, Calif., June 17-20, 1963, Paper 63-199. 9 p. Members, $0.50; nonmembers, $1.00.

Presentation of a method for estimating the velocity and size of particles blown away by a rocket exhaust impinging on the surface of the Moon. Previously developed equations are used to obtain the gasdynamics of the exhaust, needed before a particle analysis can be made. The vertical exhaust and flat horizontal surface is the only case analyzed. The numerical results obtained from the analysis are presented in the form of curves of particle velocity leading

the exhaust flow field vs particle size. The variables in the calculations are particle drag coefficient, particle density, rocket configuration, and rocket height above the surface. It is shown that, for the propulsion systems analyzed, it does not appear that any particles, large or small, will cause damage to shelters or equipment if reasonable precaution is taken in the system design.

A63-18431

A NOVEL GAS BEARING SPHERICAL-ROTOR GYROSCOPE FOR SPACE APPLICATIONS.

Frederick K. Mueller (Astro-Space Laboratories, Huntsville, Ala.).

American Institute of Aeronautics and Astronautics, Summer Meeting, Los Angeles, Calif., June 17-20, 1963, Paper 63-214. 10 p.

Members, $0.50; nonmembers, $1.00.

Description of a gyroscope which deviates completely from the conventional design concept, but does not require exotic new developments or materials. The gyroscope element of the spinning-sphere gyroscope consists basically of a solid, homogeneous, spherical rotor, suspended within a spherical outer housing by means of a hydrostatic gas bearing. Discussed are the operating principles, design features, inherent advantages, and test results of the gas-bearing spherical-rotor gyroscope with case rotation, and its possible use for vehicle orientation and stabilization in space, for the determination of the vehicle turn axis, and for the directional orientation on the lunar surface.

A63-18852

LUNAR STRATIGRAPHY.

John B. Adams (California Institute of Technology, Jet Propulsion Laboratory, Pasadena, Calif.).

American Institute of Aeronautics and Astronautics, Summer Meeting, Los Angeles, Calif., June 17-20, 1963, Paper 63-254. 10 p. 10 refs.

Members, $0.50; nonmembers, $1.00.

Contract No. NAS 7-100.

Consideration of the probable past and present processes on the Moon, and of the stratigraphic record expected to be found there. The stratigraphic principles are outlined, including the principle of superposition, the geologic time scale, and the empirical theory of uniformitarianism. Discussion of the lunar processes and stratigraphy delineates the mechanisms and effects of meteorite impacts, erosion, transportation (other than by impacts), volcanism, and radiation. Considered is the determination of the physical and chronological equivalence of strata over the lunar surface.

A63-18902

THE INFRARED SPECTRUM OF VENUS (1-2.5 μ).

V. I. Moroz (Shternberg State Astronomical Institute, Moscow, USSR).

(Astronomicheskii Zhurnal, vol. 40, Jan.-Feb. 1963, p. 144-153.) Soviet Astronomy, vol. 7, July-Aug. 1963, p. 109-115. 25 refs. Translation.

Study of the near-IR spectrum of Venus, using a spectrometer with diffraction grating. To exclude errors and identifications confused with telluric bands, spectra of the Sun and Moon are recorded under similar conditions. The observational material is listed, and tables showing both new and unidentified features are presented. Estimates on the abundance and upper limits of numerous compounds are given, and information on the chemical composition of the Venus atmosphere is summarized.

A63-18904

THERMAL CONDUCTIVITY OF LUNAR MATERIAL FROM PRECISE MEASUREMENTS OF LUNAR RADIO EMISSION.

V. D. Krotikov and V. S. Troitskii (Gor'kii State University, Institute of Radiophysics, Gor'kii, USSR).

(Astronomicheskii Zhurnal, vol. 40, Jan.-Feb. 1963, p. 158-160.) Soviet Astronomy, vol. 7, July-Aug. 1963, p. 119, 120. 12 refs. Translation.

Determination of the thermal parameter $\gamma = (K\rho C)^{-1/2}$ (where K is the thermal conductivity, ρ is the density of the lunar material, and C is the heat capacity) from precise measurements of the lunar surface temperature at both radio wavelengths and infrared. A value of 350 ± 75 is obtained for γ, averaged over the lunar disk. Taking a previously determined value for $\rho \approx 0.5$ g/cm^3, this yields a value of $(1 \pm 0.5) \times 10^{-4}$ cal/cm x sec x deg for the coefficient of thermal conductivity, which is almost 50 times the generally accepted value corresponding to dust in a vacuum. The conclusion is that the upper layer of the lunar surface does not consist of dust, but is a solid porous material (similar in structure to pumice), perhaps somewhat pulverized.

A63-18967

CRATER MÖSTING A AS THE FIRST-ORDER POINT OF TRIANGULATION ON THE MOON.

Karol Koziel (Jagellonian University, Dept. of Theoretical Astronomy, Cracow, Poland).

COSPAR, International Space Science Symposium, 4th, Warsaw, Poland, June 3-11, 1963, Paper. 5 p.

Presentation of the results of a simultaneous determination of the selenographic coordinates of the crater Mösting A and its height above the mean level of the Moon. Constants are given for the physical libration of the Moon, calculated on the basis of 3,282 observations carried out in four heliometry series in the period 1877-1915.

A63-19582

ALBEDO RADIATION FROM THE MOON AND THE PLANETS.

Satio Hayakawa (Nagoya University, Physical Institute, Nagoya, Japan).

IN: Space Research III; Proceedings of the Third International Space Science Symposium, Washington, D. C., May 2-8, 1962. Committee on Space Research — COSPAR and the U.S. National Academy of Sciences. Edited by Wolfgang Priester. Amsterdam, North-Holland Publishing Co.; New York, Interscience Publishers Division, John Wiley and Sons, Inc., 1963, p. 984-988.

Consideration of nuclear radiations induced by cosmic rays on the solid surface of the Moon or a planet. The intensities and the energy spectra of various components and their dependence on chemical composition are calculated in a semiquantitative way. The particles involved are protons and alpha particles knocked out from nuclei by (1) nuclear active particles of cosmic rays; (2) gamma rays associated with the evaporation of nuclei, as well as with the capture of neutrons; and (3) high-energy gamma rays which are decay products of neutral pions.

A63-19975

LUNAR MAPS.

E. A. Whitaker (Lunar and Planetary Laboratory, Tucson, Ariz.).

(International Union of Geodesy and Geophysics, Thirteenth General Assembly, United States National Report, 1960-1963.) American Geophysical Union, Transactions, vol. 44, June 1963, p. 456, 457.

Short discussion of recent contributions to lunar cartography. Noted are Kuiper's photographic lunar atlas, Arthur and Whitaker's photographic atlas, and a comprehensive program of lunar mapping commenced in 1960 by the Air Force Chart and Information Center, which produces maps at a scale of 1:1,000,000, with supplementary sheets at larger and smaller scales.

A63-20039

VOLCANIC PHENOMENA ON THE MOON.

Nikolai Kozyrev (Main Astronomical Observatory, Pulkovo, USSR).

Nature, vol. 198, June 8, 1963, p. 979, 980.

Brief summary of spectral observations of the crater Aristarchus made with a 50-in. reflector in order to determine whether the existence of a luminescent glow in the crater is not caused by the changes in the activity of the crater itself. Data obtained definitely establish that the emissions are of a gaseous nature, and that the source of emission rises to a certain height over the crater. It is

concluded that, because the emission of molecular hydrogen observed in the fumarole ejections of the crater cannot be the result of the photo-dissociation of water vapor, it can be assumed that molecular hydrogen is formed and accumulated in the depths of the Moon.

A63-20076
NATURE OF THE LUNAR MARIA .
Gilbert Fielder (University of London Observatory, London, England).
Nature, vol. 198, June 29, 1963, p. 1256-1260.

Presentation of data concerning the physical and chemical characteristics of lunar maria, in order to discriminate between the various specific origins which have been proposed. The considered hypotheses on the origin of the maria include accretion of meteorites and erosional detritus from slopes, accretion and erosional detritus infilling impact craters, lava flows initiated by impact in Mare Imbrium, lavas derived from low-velocity impacts, and lava flows initiated by several individual impacts. The data analyzed include the relative ages of various maria, a logarithmic plot of number of continental and post-mare (young) craters vs diameter, and the heat factors for various maria plotted against their relative age. It is concluded that the maria are essentially lava fields.

A63-20676
LUNAR SOIL SAMPLING AND TESTING.
Emanuel Azmon (Northrop Corp., Space Laboratories, Hawthorne, Calif.).
American Society for Testing and Materials, Pacific Area National Meeting, 4th, Los Angeles, Calif., Oct. 1-5, 1963, Paper 175.
15 p.

Presentation of the limited data available on the lunar environment. It is argued that when the lunar soil is to be examined, one must determine first the lunar environments under which the soil originated, and then proceed to select the proper tests for the soil. Meteorites, which are the only extraterrestrial and possibly lunar soil samples available, are discussed and their igneous origin is postulated. Described is a series of experiments conducted to examine certain phenomena in the genesis of igneous rocks under controlled conditions of temperature-pressure, with special emphasis on textures which are due to rapid heating and cooling, partial melting, and coalescence of crystallites in the solid state. Results are presented for pressures of 40,000 atm and temperatures of 1,000°C.

A63-21139
ANALYTICAL INSTRUMENTATION IN SPACE EXPLORATION.
Edgar L. Steele (Agricultural and Mechanical College of Texas, Activation Analysis Research Laboratory, College Station, Tex.).
Analytical Chemistry, vol. 35, Aug. 1963, p. 23A-30A, 32A, 35A-38A. 18 refs.

Discussion of instruments useful in space exploration and the factors to be considered in their design. The following sampling of analytical instruments is presented: alpha particle scattering instruments for the analysis of the lunar surface, an X-ray diffractometer, gas-chromatographic equipment, an X-ray spectrometer, and nuclear activation analysis instruments. Brief descriptions are included of the organizational structure of NASA and its space-science and proposed analytical programs.

A63-21282
RADIO CHARACTERISTICS OF LUNAR SURFACE MATERIAL.
K. M. Siegel (University of Michigan, Ann Arbor, Mich., and Conductron Corp., Ann Arbor, Mich.).
IN: 12th INTERNATIONAL ASTRONAUTICAL CONGRESS, PROCEEDINGS, vol. 2. Washington, D.C., Oct. 1-7, 1961. New York and London, Academic Press, Inc., 1963, p. 662-669. 13 refs.
NASA-supported research, Grant No. 6-4-59.

The different theories of radio scattering from the Moon are compared and analyzed. The theories pertinent to the subject, involving radiation from the Moon, are discussed. The electromagnetic and thermodynamic constants of the lunar surface are obtained. It is concluded that present experimental data yields completely consistent results (independent of the wavelength of the radiation, whether the source is coherent or incoherent and independent of the pulse length used). The electromagnetic constants obtained are different from those found on Earth.

A63-21292
LUNAR AND PLANETARY SURFACE EXPLORATION.
Ernst Stuhlinger (NASA, George C. Marshall Space Flight Center, Huntsville, Ala.).
IN: 12th INTERNATIONAL ASTRONAUTICAL CONGRESS, PROCEEDINGS, vol. 2. Washington, D.C., Oct. 1-7, 1961. New York and London, Academic Press, Inc., 1963, p. 801-805.

Brief summary of the lunar and planetary exploration program of NASA. Noted are the three lunar vehicles (Ranger, Surveyor, Prospector), and the two planetary vehicles (Mariner, Voyager). The Ranger and Mariner vehicles are to contain "drop capsules" whose impact will be softened by retro-rockets and by crush layers. Prospector and Voyager should be capable of roving across the surface on inflatable wheels. Drop-capsule instruments will observe temperatures, quakes and tectonic tremors, and atmospheric data, while the soft-landers will also be equipped with: TV; X-ray and γ-ray diagnostic apparatus; detectors for surface radioactivity, for magnetic fields, for meteorites, and for organic matter; and a surface drill to bore holes for probes and to take samples.

A63-21384
MOON ATLAS.
V. A. Firsoff.
New York, Viking Press, Inc., 1962. 32 p.
$10.

General atlas of the Moon, with maps, photographs of progressive phases, a gazetteer, and a descriptive text, all of which can be used in identification of surface formations. The results of prolonged research are presented in the form of a three-color map of the formative fractures of the lunar surface and associated features, and in a set of spherical projection photographs which eliminate the foreshortening at the Moon's limb. A relief map in color gives a perspicuous presentation of the Moon's mountains, craters, and clefts. Quadrant maps show more detail. The tectonic map in three-color line gives the lines of crustal weakness (faults, fractures, overthrusts, crater chains) along which land movements have occurred. It is possibly the first map of its kind. Spherical projection photographs show various aspects of the Moon's limb regions vertically from above. Explanatory charts and captions are provided. A descriptive classification of lunar surface features gives a concise account of plains, mountains, craters, clefts, ray systems, and other formations.

A63-21457
APPLICATIONS OF OPTICAL "MASERS" TO SPACE RESEARCH [APPLICAZIONI DEI "MASER" OTTICI ALLE RICERCHE SPAZIALI].
Giorgio Fiocco (Massachusetts Institute of Technology, Dept. of Electrical Engineering and Research Laboratory of Electronics, Cambridge, Mass.).
(International Communications Congress, 10th, Genoa, Italy, Oct. 7-12, 1962.)
Missili, vol. 5, Apr. 1963, p. 73-78. In Italian.

Consideration of the characteristics and some applications of optical masers in radar devices suitable for astronomical and geophysical research. Included is a simplified chart of the various equipment used to obtain optical echoes from the Moon surface. Experiments conducted to receive echoes from the Moon are described.

A63-21611
THE RELATION OF TEKTITES TO LUNAR IGNEOUS ACTIVITY.
Paul D. Lowman, Jr. (NASA, Goddard Space Flight Center, Greenbelt, Md.).
Icarus, vol. 2, June 1963, p. 35-48. 71 refs.

Discussion of the origin of tektites. It is suggested that they may have been derived from silicic igneous rocks, specifically rhyolitic tuffs, forming the upper layers of the lunar maria. The essentially igneous nature of tektites is indicated by their bulk composition, their restricted compositional range, and the high probability that they have not been derived from sedimentary rocks by random processes such as meteoritic impact. The differences between tektites and normal igneous rocks probably reflect their formation by extremely high-temperature fusion of previously solid igneous rock. It is shown that, if the Moon originally had a chondritic composition, the fusion curve of the lunar material should intersect the thermal gradients computed by MacDonald at 400-500 km depth, depending on the slope of the fusion curve, even if the Moon had originally been at 0°C. Additional heat sources such as the kinetic energy of accretion and capture-induced internal friction would probably have raised the temperature well above the "cold" Moon gradient. Magmas generated by partial fusion of the assumed chondritic material should be basaltic. It is proposed that the maria are the lunar equivalents of terrestrial lopoliths such as the Bushveld and Sudbury complexes, which are large basins filled mainly with basaltic rock overlain by tuffs, rhyolites, and granophyres. Tektites may have been derived from these silicic rocks by some process involving meteoritic impact.

A63-21754
PHOTOMETRIC STUDIES OF COMPLEX SURFACES, WITH APPLICATIONS TO THE MOON.
Bruce Hapke and Hugh Van Horn (Cornell University, Center for Radiophysics and Space Research, Ithaca, N. Y.).
Journal of Geophysical Research, vol. 68, Aug. 1, 1963, p. 4545-4570. 28 refs.
Grant No. NsG-119-61.

Measurement of the reflection laws of a wide variety of surfaces The factors that govern the optical scattering characteristics of complex surfaces are discussed, and the properties of surfaces that scatter light like the Moon are specified. Surfaces of solid rocks, volcanic slags, or coarsely ground rock powders do not have the intricate structure necessary for backscattering light strongly, but finely pulverized dielectric particles can build extremely complex surfaces that can reproduce the lunar scattering law. It is concluded that the surface of the Moon is covered with a layer of fine rock dust composed of particles of the order of 10-micron average diameter and that 90% of the volume of the surface layer is voids.

A63-21755
A THEORETICAL PHOTOMETRIC FUNCTION FOR THE LUNAR SURFACE.
Bruce W. Hapke (Cornell University, Center for Radiophysics and Space Research, Ithaca, N. Y.).
Journal of Geophysical Research, vol. 68, Aug. 1, 1963, p. 4571-4586. 15 refs.
Grant No. NsG-119-61.

Theoretical derivation of a formula describing the observed photometric properties of the lunar surface. Functions for both the differential and integral brightness are obtained. The model surface on which the derivation is based consists of a semi-infinite, porous layer of randomly placed obscuring objects suspended in depth in such a way that the interstices separating them are interconnected. A layer of fine, loosely compacted dust is in the category of surfaces described by this model, but volcanic foam is not. The shape of the photometric curve depends on the fractional void volume. Bulk densities of the order of 0.1 that of solid rock are implied for the upper layers of the surface of the Moon.

A63-22079
ESTIMATE OF NEUTRON ALBEDO ON THE MOON'S SURFACE RESULTING FROM COSMIC RADIATION.
M. V. K. Appa Rao (University of Rochester, Dept. of Physics and Astronomy, Rochester, N. Y.).
Science, vol. 141, Aug. 9, 1963, p. 530, 531.
Grant No. AF-AFOSR-62-32.

Calculation of neutron albedo on the Moon caused by cosmic radiation. Since the Moon does not seem to have an atmosphere, its surface is exposed to bombardment by cosmic radiation. This results in spallation of the surface nuclei, yielding neutrons, some of which constitute albedo. In order to estimate the albedo, it is necessary to know the intensity and composition of cosmic radiation, the composition of the Moon's surface, and the cross section for the production of neutron albedo. The composition of the Moon's surface is inferred only from telescopic observation. A table shows the values of neutron albedo from the top 1 cm^3 of the Moon's surface, assuming the composition to be basaltic rock.

A63-22205
THE HEAT BALANCE OF THE LUNAR SURFACE LAYER DURING A LUNATION.
V. D. Krotikov and O. B. Shchuko (Gor'kii State University, Radiophysics Institute, Gor'kii, USSR).
(Astronomicheskii Zhurnal, vol. 40, Mar.-Apr. 1963, p. 297-303.) Soviet Astronomy, vol. 7, Sept.-Oct. 1963, p. 228-232. 11 refs.
Translation.

Presentation of BESM-2 computer calculations of the heat balance of the lunar surface during a lunation for the homogeneous model of the lunar surface. The computations provide a basis for deriving the temperature distribution function over the lunar surface for any phase, in a Fourier series representation. The results indicate that the change in the surface temperature for the subsolar point in each of the cases considered failed to exceed 2.0%. This means that the lunar surface may be assumed to be an absolute blackbody with sufficient accuracy in heat-balance calculations.

A63-22225
TERRESTRIAL OCEANIC RIDGES AND LUNAR MARE RIDGES.
Gilbert Fielder (University of London Observatory, London, England).
Nature, vol. 199, Aug. 3, 1963, p. 473. 14 refs.

Discussion of a possible analogy between terrestrial ocean ridges and lunar wrinkle (or mare) ridges. Among the similarities noted is the fact that some terrestrial ridges terminate by wedging out and others end in major strike-slip faults; precisely these properties describe the terminal stages of lunar wrinkle ridges, such as the furcating wrinkle ridge in Sinus Aestuum which slices the Apennines in strike-slip faults as far as the ruined ring Marco Polo. The fact that no evidence exists for recent continental drift on the Moon is briefly discussed.

A63-22742
EFFECT OF GRAVITY ON THE MOBILITY OF A LUNAR VEHICLE.
George A. Costello (University of Illinois, Dept. of Theoretical and Applied Mechanics, Urbana, Ill.) and Donald L. Dewhirst (Chrysler Corp., Defense Operations Division, Detroit, Mich.).
AIAA Journal, vol. 1, Sept. 1963, p. 2157-2159.

Presentation of a dimensional analysis for determining the effect of gravity on the tractive effort of a vehicle moving in a soil. The theory shows that the effect of lunar gravity may be simulated by changing controlled variables. Test results are presented for a six-wheel model operating in 1/4-in. gravel. These results show that, for a vehicle traveling in a horizontal plane on a cohesionless soil, the percent slip, for a given ratio of drawbar pull to vehicle weight, is practically unaffected by changes in gravity.

A63-23417
TECHNOLOGY OF LUNAR EXPLORATION. PROGRESS IN ASTRONAUTICS AND AERONAUTICS. VOL. 10.
Edited by Clifford I. Cummings and Harold R. Lawrence.
(California Institute of Technology, Jet Propulsion Laboratory, Pasadena, Calif.).
New York and London, Academic Press, Inc., 1963. 450 p. $13.75.

Collection of papers concerning the various stages of accomplishment of a lunar mission, involving landing on or orbiting the Moon, and returning to Earth. The papers are divided into six sections. The first is devoted to the problem of trying to define the lunar environment, including its internal structure, and what might be encountered in some of the initial lunar flight programs.

The second section explores the problems associated with the limitation imposed upon lunar missions by the launch vehicles and launching facilities, including launch, midcourse, and rendezvous techniques. The third section examines spacecraft systems and techniques required for lunar missions. Technology and specific subsystems are discussed in relation to the requirements imposed by specific mission objectives. The fourth describes the actual landing on the Moon and subsequent surface operations, for which the Apollo program is considered. The fifth covers the lunar launch, return flight, re-entry, and subsequent landing on Earth. The sixth section reports the status of the projects which represent the U.S. lunar exploration program. The papers are individually abstracted and indexed in this issue.

A63-23418
INTERNAL STRUCTURE OF THE MOON.
Zdenek Kopal (University of Manchester, Manchester, England, and California Institute of Technology, Jet Propulsion Laboratory, Pasadena, Calif.).
(American Rocket Society, Lunar Missions Meeting, Cleveland, Ohio, July 17-19, 1962.)
IN: TECHNOLOGY OF LUNAR EXPLORATION. PROGRESS IN ASTRONAUTICS AND AERONAUTICS. VOL. 10. Edited by Clifford I. Cummings and Harold R. Lawrence. New York and London, Academic Press, Inc., 1963, p. 3-33. 38 refs.
Contract No. NAS 7-100.

Review of theoretical and experimental investigations of the processes operative in the interior of the Moon, and of the phenomena these processes are likely to produce. Considered are: (1) the chemical composition of the Moon, (2) the hydrostatic equilibrium of the lunar interior, (3) the thermal history of the Moon, and (4) the escape of volatiles from the lunar interior. It is shown that a mean density of 3.34 g/cm^3 suggests the Moon to be of a composition similar to that of the terrestrial mantle (or the non-volatile fraction of the solar atmosphere), but is either deficient in iron or enriched by some common low-density substance. Deviations of the mass of the Moon from hydrostatic equilibrium are small but significant. In particular, the difference of lunar angular momenta about the three principal axes of inertia are inconsistent with a hydrostatic equilibrium at any distance from the Earth. The near-sphericity of the Moon reveals that its crust cannot sustain large-scale differences in level exceeding 1 to 2 km; and the absence of free physical libration signifies that the rigidity of the lunar globe must be smaller than that of the Earth.

A63-23419
A LUNAR SURFACE MODEL FOR ENGINEERING PURPOSES.
Victor P. Head (RCA, Astro-Electronics Division, Lunar and Space Exploration Section, Princeton, N.J.).
(American Rocket Society, Lunar Missions Meeting, Cleveland, Ohio, July 17-19, 1962.)
IN: TECHNOLOGY OF LUNAR EXPLORATION. PROGRESS IN ASTRONAUTICS AND AERONAUTICS. VOL. 10. Edited by Clifford I. Cummings and Harold R. Lawrence. New York and London, Academic Press, Inc., 1963, p. 35-81. 24 refs.

Theoretical analysis of the subresolution surface geometry and soil strength of the lunar maria, by using data from various experimental investigations. Continuous and overlapping craterlets in sintered granular rock of strength proportional to depth are predicted for the least formidable areas, and are demonstrated by table-top models of the lunar surface and by statistical and thermomechanical studies. Scale factors required for dynamic model testing of a lunar surface mechanism at Earth gravity are derived and tabulated, taking into account the interaction between model mechanism and environmental model terrain.

A63-23420
U. S. AIR FORCE CARTOGRAPHIC SUPPORT OF LUNAR MISSIONS.
Robert W. Carder (USAF, Aeronautical Chart and Information Center, St. Louis, Mo.).
(American Rocket Society, Lunar Missions Meeting, Cleveland, Ohio, July 17-19, 1962.)
IN: TECHNOLOGY OF LUNAR EXPLORATION. PROGRESS IN ASTRONAUTICS AND AERONAUTICS. VOL. 10. Edited by Clifford I. Cummings and Harold R. Lawrence. New York and London, Academic Press, Inc., 1963, p. 83-96.

Brief review of an Air Force program for publishing a series of photographic and cartographic products of the Moon. Described are illustrative examples of map sections and of rectified lunar photographs obtained by means of globe projection.

A63-23421
REACTION OF THE LUNAR SURFACE TO THE IMPACT OF A LUNAR PROBE.
J. William Gehring, Jr. and David W. Sieck (General Motors Corp., Hyperballistics Group, Santa Barbara, Calif.).
(American Rocket Society, Lunar Missions Meeting, Cleveland, Ohio, July 17-19, 1962.)
IN: TECHNOLOGY OF LUNAR EXPLORATION. PROGRESS IN ASTRONAUTICS AND AERONAUTICS. VOL. 10. Edited by Clifford I. Cummings and Harold R. Lawrence. New York and London, Academic Press, Inc., 1963, p. 97-136. 15 refs.

Experimental investigation of the variables associated with a projectile impacting on targets designed to simulate the lunar surface. The tests consisted in firing projectiles of varied mass, material, and velocity into a variety of target materials. Observations were made, and quantitative data were obtained for the magnitude of the luminosity of the impact flash, the duration of the flash, and the spectrum of emitted light. Also, high-speed optical pictures were made to determine the disposition of the impacting projectile and the debris ejected from the resultant crater. From the analysis of the experimental data, an estimate can be made of the impact flash likely to be observed on impact of a lunar probe on the Moon's surface.

A63-23436
MAN-TO-THE-MOON AND RETURN MISSION UTILIZING LUNAR-SURFACE RENDEZVOUS.
John G. Small and W. J. Downhower (California Institute of Technology, Jet Propulsion Laboratory, Systems Design Section, Pasadena, Calif.).
(American Rocket Society, Lunar Missions Conference, Cleveland, Ohio, July 17-19, 1962.)
IN: TECHNOLOGY OF LUNAR EXPLORATION. PROGRESS IN ASTRONAUTICS AND AERONAUTICS. VOL. 10. Edited by Clifford I. Cummings and Harold R. Lawrence. New York and London, Academic Press, Inc., 1963, p. 483-532.
Contract No. NAS 7-100.

Examination of the problems involved in placing a man on the Moon at an early date. A lunar rendezvous technique is suggested as one of the possible solutions. Among the mission procedures considered are: escape from Earth, transit to the Moon, lunar launch and injection, return transit to Earth, support and protection of human crew members throughout all phases, and abort capability for the manned portion of the system. Because of the complexity of this mission, each module is examined separately. Critical areas are identified and operational sequences are outlined.

A63-23449
RANGER PROJECT STATUS.
J. D. Burke (California Institute of Technology, Jet Propulsion. Laboratory, Pasadena, Calif.).
(American Rocket Society, Lunar Missions Meeting, Cleveland, Ohio, July 17-19, 1962.)
IN: TECHNOLOGY OF LUNAR EXPLORATION. PROGRESS IN ASTRONAUTICS AND AERONAUTICS. VOL. 10. Edited by Clifford I. Cummings and Harold R. Lawrence. New York and London, Academic Press, Inc., 1963, p. 855-875.
Contract No. NAS 7-100.

Review of the accomplishments of the Ranger Project, which was planned to produce scientific data on the environment and composition of the Moon for use in the NASA manned lunar exploration program. The Ranger spacecraft carry experiments for

measuring radiation levels, determining lunar radar reflectivity characteristics, taking and transmitting TV pictures of the surface, and rough-landing a survivable capsule instrumented to measure seismic disturbances on the Moon. Later flights will carry a high-resolution TV subsystem. Rangers I and II remained in low Earth orbit because of failures in the booster vehicle. Launch-vehicle guidance malfunctions resulted in out-of-tolerance injection velocity for Ranger III, which yielded useful data not completed successfully. Ranger IV was injected normally but apparent loss of power to the Central Computer and Sequencer prevented performance of timed events or acceptance of commands; the spacecraft was tracked to impact on the far side of the Moon on April 26, 1962.

A63-23475
NAVIGATIONAL ENVIRONMENT OF THE MOON.
Earl J. McCartney (Sperry Rand Corp., Sperry Gyroscope Co., Marine Division, Garden City, N. Y.).
(Institute of Navigation, Eastern Regional Meeting, New York, N. Y., Nov. 8, 1962.)
Navigation, vol. 10, Summer 1963, p. 154-160.

Discussion of the relation between the lunar environment and lunar navigation requirements. Several Earth navigation methods are evaluated in terms of the lunar environment. Problems of solar radiation, meteors, lunar weather, dust, and topography are considered. It is indicated that celestial methods could be extremely valuable for navigation on the Moon. It is therefore suggested that the lunar almanac tables be constructed and made available for lunar navigation.

A63-23478
PICTORIAL GUIDE TO THE MOON.
Dinsmore Alter (Griffith Observatory, Los Angeles, Calif.).
New York, Thomas Y. Crowell Co., 1963. 183 p.
$6.95.

Detailed presentation of information about the Moon, accompanied by over 100 photographs of the lunar surface in different phases and varying conditions of illumination. Considered are: (1) early observations of the Moon; (2) contemporary studies; (3) the lunar surface, including mountains, craters, plains and seas; (4) lunar rays; (5) tidal forces; and (6) efforts to land on the Moon. A glossary defines terms in the text which might be unfamiliar to the layman.

A63-23640
ISOTHERMS OF CRATER REGIONS ON THE ILLUMINATED AND ECLIPSED MOON.
J. M. Saari and R. W. Shorthill (Boeing Co., Scientific Research Laboratories, Seattle, Wash.).
Icarus, vol. 2, Aug. 1963, p. 115-136. 26 refs.
Contract No. AF 18(600)-1824.

Review of scan programs of the Moon using a thermistor bolometer over a variety of crater regions, both under illumination near the full Moon and during the September 5, 1960 eclipse. Isotherms are constructed and related to surface features. All five of the rayed craters observed during the eclipse exhibited anomalous cooling, the effect being greatest for Tycho and progressively less for Aristarchus, Copernicus, Proclus, and Kepler. Several explanations of the phenomenon are discussed, including thinner dust layer, lower emissivity, and subsurface heating. Variations observed on the illuminated Moon can be attributed to differences in albedo and local inclinations of the surface. Further investigations are indicated to quantitatively relate the observed temperature differentials to measured values of albedo and inclination, and to other properties of the surface.

A63-23643
A HYPOTHESIS THAT THE SURFACE OF THE MOON IS COVERED WITH NEEDLE CRYSTALS.
Albert R. Hibbs (California Institute of Technology, Jet Propulsion Laboratory, Pasadena, Calif.).
Icarus, vol. 2, Aug. 1963, p. 181-186. 13 refs.
Contract No. NAS 7-100.

Description of an alternate hypothesis to the powdered-rock idea for the surface material of the Moon, namely, that the surface which would result from impact phenomena as a formative process is composed primarily of a mat of needle crystals. The hypothesis is based on laboratory experiments on the condensation of material from a vapor to a solid phase in a region of pressure and temperature that precludes a liquid phase. This is the region of temperature and pressure that would apply to material condensing from the vapor to a solid phase on the surface of the Moon or, generally, in interplanetary space. It is suggested that the primary solid material of the solar system was also of this form, as are the meteors which account for the faint meteor anomaly. It is further suggested that even the surface of the Moon resulting fundamentally from volcanic processes would, as a result of subsequent bombardment of small particles, be covered with at least a thin fuzz of needle crystals.

A63-23791
PENETRATION OF SPACECRAFT BY LUNAR SECONDARY METEOROIDS.
Willard S. Boyle and G. Timothy Orrok (Bellcomm, Inc., Space Science and Exploratory Studies Division, Washington, D. C.).
AIAA Journal, vol. 1, Oct. 1963, p. 2402-2404.

General examination of the problem of the spacecraft at rest on the lunar surface, in order to set limits on the probability of puncture by secondary meteoroids generated at the surface. The fact that the total kinetic energy available for the secondary particles is bounded by the kinetic energy of the primary particle is used to find a restriction on the integrated energy spectrum of the secondary particles; the increase in the flux of particles exceeding a given energy is derived. It is assumed that the thickness of protective skin penetrated by a particle depends only on the kinetic energy; it is shown that the probability of puncture is, at most, increased by only a small factor.

A63-24112
POSSIBLE ORIGIN OF THE LUNAR WALLED PLAIN PTOLEMAEUS.
R. B. Strom and A. Palm (University of California, Space Sciences Laboratory, Berkeley, Calif.).
Nature, vol. 199, Sept. 14, 1963, p. 1052-1054. 12 refs.
Grant No. NsG 145-61.

Investigation of the tectonic interrelations between the features in Ptolemaeus and the grid lineaments in the adjacent terrae. A generalized map of the regional grid systems and the pertinent Ptolemaean floor features is presented. The Imbrium radial system of valleys and ridges is described, which radiates from the border of Mare Imbrium for hundreds of kilometers and predominates in the vicinity of Ptolemaeus. The tectonic relationships between the Imbrium radial system and the Ptolemaean ghost features suggest that the formation of Ptolemaeus may have been contemporaneous with that of Mare Imbrium, the possible stages of the Ptolemaean evolution are noted.

1964

A64-10163
COMMUNICATIONS.
Sidney Metzger.
Astronautics and Aerospace Engineering, vol. 1, Nov. 1963, p. 110-113.

Review of the state-of-the-art of communication satellites. Recent developments in space tracking techniques and radio command systems are discussed. The objectives of the Mariner experiment are outlined. Recent experiments are briefly reviewed concerning high-precision, long-range tracking and Moon mapping, such as the NASA experiment of precision optical tracking with the S-66 geodetic satellite. Advances in technology made in the flights of Telstar I and II, Relay I, and Syncom I and II are discussed with emphasis on satellite weight reduction, attaining a 24-hr orbit, continuous communication via satellite for a 24-hr period, station keeping, and establishing a man-made orbiting dipole belt.

A64-10387
THE ORIGIN OF TEKTITES.
John A. O'Keefe (NASA, Goddard Space Flight Center, Greenbelt, Md.).

IN: TEKTITES.
Edited by John A. O'Keefe.
Chicago and London, University of Chicago Press, 1963, p. 167-188. 75 refs.

Comparison and evaluation of the terrestrial and lunar hypotheses for the origin of tektites. Those aspects of tektite formation for which there is relative certainty are first considered, including their origin in meteoritic impact, their short time in space as tektites, and the supposition that debris of lunar origin must be reaching the Earth in some form. Arguments for the validity of the hypothesis of terrestrial origin are delineated, including the Earth-like chemistry and isotope ratios, the distribution in megameter-size strewnfields, and the relation of the Ries Crater to moldavites. Arguments against this hypothesis include the observation that impact glasses are generally unlike tektites, and the difficulty of explaining distribution from ground impact. This hypothesis of terrestrial origin is rejected, and the reasons for accepting that of lunar origin are outlined.

A64-11227
NEW DATA ON THE STRUCTURE OF THE LUNAR SURFACE [NOVOE O STROENII LUNNOI POVERKHNOSTI].
N. F. Kuprevich (Akademiia Nauk, Glavnaia Astronomicheskaia Observatoriia, Pulkovo, USSR).
Astronomicheskii Zhurnal, vol. 40, Sept.-Oct. 1963, p. 889-896. In Russian, with summary in English.

Presentation of the results of observations of the Moon in the infrared spectral region 0.9 - 2.3 μ, using a television system. The equipment used is briefly described. Photographs of the Moon, obtained in the visible and infrared spectral regions, are compared, and details on the structure of the lunar surface, detected in the infrared photographs, are described. It is assumed that the observed increase in the contrast of infrared photographs can be explained by a decrease in the luminescence of separate details of the lunar surface in the infrared. It is suggested that the dust layer on the lunar surface is probably very thin or completely absent.

A64-11461
THE GEOLOGY OF THE LUNAR BASE.
Jack Green (North American Aviation, Inc., Space and Information Systems Div., Downey, Calif.).
IN: ADVANCES IN THE ASTRONAUTICAL SCIENCES. VOL. XI.
Edited by Horace Jacobs.
(American Astronautical Society, Annual Meeting, 8th, Washington, D. C., Jan. 16-18, 1962, Proceedings.)
North Hollywood, Calif., Western Periodicals Co., 1963, p. 455-514. 54 refs.

Study of the geology of the lunar surface in view of requirements for the selection of a site and the construction and maintenance of a lunar base. Covered are lunar volcanic mechanisms, the macrorelief of lunar terrain, mega- and macro relief terrain features, mineralization, thermal sources, and base considerations. It is indicated that a greater sensitivity to volcanic phenomena might exist on the Moon because of tidal and gravity effects. Earth-induced tides would tend to fracture the lunar crust and promote the generation of magma. Bubbles would tend to nucleate deeper on the Moon and expand faster than they rise relative to terrestrial rates. A more explosive type of volcanism might therefore be or have been produced. Details of lunar surface features support a volcanic origin. Base site selection may have to compromise the requirements of many scientific and engineering disciplines. Early base operations will probably be controlled by trajectory considerations and terrain and mineralization features of the base site. For this reason, a nonpolar caldera-type lunar crater will probably be superior to an impact crater or a basaltic flood plain. In later base operations, more independence may permit base location, perhaps, in a polar location adjacent to eternally shadowed zones which may be mineralized; here, continuous sunlight is available for ecological functions. At least seven technologies may be required to maintain the lunar base, all of which involve the geoscientist: (1) tunneling and base construction, (2) extraction of gases from rock froths, (3) extraction of water from volcanics, (4) the processing of sulfur, (5) mineral dressing using existing raw materials, (6) the metallurgy of basalt, and (7) the selective volatilization of rocks using plasma techniques. The significance of the topographic law in lunar craters is discussed from the standpoint of localizing mineralization, including water.

A64-11463
THE CRATER CONTRIBUTION TO SURFACE ROUGHNESS OF THE MOON.
M. Kornhauser (General Electric Co., Missile and Space Vehicle Dept., Philadelphia, Pa.).
IN: ADVANCES IN THE ASTRONAUTICAL SCIENCES. VOL. XI.
Edited by Horace Jacobs.
(American Astronautical Society, Annual Meeting, 8th, Washington, D. C., Jan. 16-18, 1962, Proceedings.)
North Hollywood, Calif., Western Periodicals Co., 1963, p. 517-525.

Discussion of some of the problems associated with the roughness of the lunar surface due to craters. By plotting numbers of craters versus size and extrapolating below the size limit of telescopic resolution, it is found that less than ten per cent of the Moon's surface is covered by craters. In local areas, however, the surface may be almost entirely covered by craters. Slopes inside the craters are an inverse function of size, the 10,000 ft diameter crater having a maximum slope of 28° while the 1,000 ft diameter crater has a maximum slope of 46°. It is concluded that some areas of the Moon should be easy to traverse, while others must be impassable. The crater size distribution on the Moon does not correlate well with the size distribution of sporadic meteoroids currently existing in Earth-Moon space, indicating that this may be a function of geologic time.

A64-11581
RADAR REFLECTION FROM A ROUGH MOON DESCRIBED BY A COMPOSITE CORRELATION FUNCTION.
Fred B. Daniels (U.S. Army, Electronics Research and Development Laboratories, Fort Monmouth, N.J.).
(U.S. Army, ELRDL TR 2314.)
Journal of Geophysical Research, vol. 68, Dec. 1, 1963, p. 6251-6254. Abridged.

Examination of the theory of radar reflections from a rough planetary surface for the case of deep modulation where the surface correlation function consists of two components having greatly different structure sizes. It is found that a modified superposition principle holds for the angular power spectrum and that the individual components may be detectable by high-resolution pulse techniques. Recent lunar experiments by Mehuron are found to show the existence of two such components. The theory also leads to the conclusion that the angular power spectrum of the echoes cannot be computed from the results of CW measurements for the type of surface considered.

A64-11608
THE GEOLOGY OF THE LUNAR BASE. Appendix A - LUNAR BASE CHRONOLOGY. Appendix B - SIMULATED LUNAR BASE SITES.
Jack Green (North American Aviation, Inc., Space Sciences Laboratory, Downey, Calif.).
New York Academy of Sciences, Annals, vol. 105, art. 9, Oct. 22, 1963, p. 491-625. 203 refs.

Study of the geological nature of the Moon in view of the requirements for site selection and the construction and maintenance of a lunar base. Covered are such topics as volcanic mechanisms, the microrelief of lunar terrain, megarelief and macrorelief terrain features, mineralization, thermal sources, base-site considerations, and base technology. It is concluded that, from a consideration of tidal and gravity effects operative or once operative on the Moon, one might expect a greater sensitivity to volcanism on the Moon than on the Earth. The advantages offered the lunar base by volcanic terrain include lava tubes, caves, and fissures. In addition, mineralization, such as ice or sulfur, can conceivably exist in volcanic environments but not in impacted ones. Thermal sources, including volcanos in lunar calderas, and fracture and ray intersections should be considered in selecting the lunar base. This selection may have to compromise the requirements of many scientific disciplines. The first base will probably be determined by terrain and mineralization advantages.

A64-12346
SIGNIFICANT MEASUREMENT IN THE LUNAR PHOTOGRAPH.
L. Harold Spradley (USAF, Aeronautical Chart and Information Center, St. Louis, Mo.).

(American Society of Photogrammetry - American Congress of Surveying and Mapping, Convention, Washington, D.C., Mar. 24-30, 1963.)
Photogrammetric Engineering, vol. 29, Nov. 1963, p. 941-946.

Discussion of difficulties involved in analyzing photographs of the Moon taken with astronomical telescopes. Problems associated with obtaining lunar photographs are reviewed, and groups of existing lunar photographs are discussed. Methods for analyzing these photographs are presented, and the relative effectiveness and limit of application of each method are discussed.

A64-12632
THE LUNAR SURFACE: INTRODUCTION.
Frederick E. Wright, F. H. Wright, and Helen Wright (Mount Wilson and Palomar Observatories, Palomar, Calif.).
IN: THE MOON, METEORITES, AND COMETS. Vol. IV - The Solar System.
Edited by Barbara M. Middlehurst and Gerard P. Kuiper.
Chicago and London, University of Chicago Press, 1963, p. 1-56. 303 refs.

Review of pertinent observations which contribute to our present knowledge of the lunar surface. Examined are: the conditions which might prevail at the lunar surface; lunar radiation; photometry and colorimetry of the lunar surface and the polarization of reflected or scattered light; mapping and topographic methods; the volcanic and the meteorite-impact hypotheses for the origin of lunar features; and observations on maria, mountain ranges, rilles and rays. Lunar ballistics are discussed in some detail.

A64-12633
SELENOGRAPHY.
D. W. G. Arthur (Arizona, University, Lunar and Planetary Laboratory, Tucson, Ariz.).
IN: THE MOON, METEORITES, AND COMETS. Vol. IV - The Solar System.
Edited by Barbara M. Middlehurst and Gerard P. Kuiper.
Chicago and London, University of Chicago Press, 1963, p. 57-89. 15 refs.

Detailed description of the formulas and computing methods of mathematical selenography. The discussion is strictly geometric and kinematic and is based on the empirical laws of Cassini. Included in the discussion are: (1) the optical librations; (2) elements of the mean lunar equator; (3) rigorous and approximate formulas for the optical librations; (4) conversion of geocentric to topocentric librations; (5) the Moon's heliocentric coordinates; (6) the position angle of the lunar terminator; (7) the Moon's topocentric and selenographic coordinates; (8) the reduction of micrometric measures for position; (9) relative lunar altitudes from shadow measurements; and (10) the determination of crater diameters.

A64-12634
INVESTIGATION OF THE FAR SIDE OF THE MOON WITH THE AID OF ROCKETS. Appendix - SCHEMATIC MAP OF THE FAR SIDE OF THE MOON.
Y. N. Lipskii (Shternberg Astronomical Institute, Moscow, USSR), I. I. Breydo, and D. E. Shchegolev (Main Astronomical Observatory, Pulkovo, USSR).
IN: THE MOON, METEORITES, AND COMETS. Vol. IV - The Solar System.
Edited by Barbara M. Middlehurst and Gerard P. Kuiper.
Chicago and London, University of Chicago Press, 1963, p. 90-122.

Discussion of lunar observations made with the Soviet Lunik 3 (1959 Theta 1). Noted are the instruments carried by the rocket, the method of temperature control, and the directional and orientation controls. Outlined are the considerations involved in the choise of a trajectory. Examined are the techniques employed to obtain an optimum sequence of photographs of different parts of the surface, the scanning method used in transmission of the photographic data, and the processing of the material on Earth. Discussed are the details of the lunar features observed on the far side of the Moon; the various formations discerned are grouped in three categories of probable reliability. Presented are several reproductions made by recordings on magnetic tape of the signals from the original negative. The plotting of a schematic map of the far side of the Moon is treated in an Appendix.

A64-12635
EVALUATION OF THE SOVIET PHOTOGRAPHS OF THE MOON'S FAR SIDE.
E. A. Whitaker (Arizona, University, Lunar and Planetary Laboratory, Tucson, Ariz.).
IN: THE MOON, METEORITES, AND COMETS. Vol. IV - The Solar System.
Edited by Barbara M. Middlehurst and Gerard P. Kuiper.
Chicago and London, University of Chicago Press, 1963, p. 123-128.

Discussion of the photographic techniques used to extract a maximum of information from published photographs of the far side of the Moon, obtained with both an 8-in. and a 20-in. focus lens. A schematic map prepared by tracing from the photographs made by the Soviet Lunik 3 (1959 Theta 1) is presented. The extraction techniques are claimed to have greatly simplified the evaluation of the Lunik III photographs and the identification of features of both earthward and averted hemispheres. Straight lines caused by electronic interference and incomplete development were eliminated, and recentered photographs were obtained.

A64-12636
THE SCATTERING PROPERTIES OF THE LUNAR SURFACE AT RADIO WAVE LENGTHS.
J. V. Evans and G. H. Pettengill (Massachusetts Institute of Technology, Lincoln Laboratory, Cambridge, Mass.).
IN: THE MOON, METEORITES, AND COMETS. Vol. IV - The Solar System.
Edited by Barbara M. Middlehurst and Gerard P. Kuiper.
Chicago and London, University of Chicago Press, 1963, p. 129-161 58 refs.

Discussion of the characteristics of signals reflected from the Moon, in the light of the most recent and reliable results. Examined are the different methods currently employed to obtain information from radar systems concerning the gross surface roughness of the Moon. Some relevant theoretical models developed to explain radar scattering from a rough surface are presented, and are compared with actual experimental results. Two kinds of surface roughness are known to exist on the Moon's surface from visual observations; these are (1) a large-scale structure which has a scale tens of kilometers across and (2) a small-scale structure well below the limit of optical resolution which gives rise to the uniform brightness of the lunar disk. The radar observations yield information about intermediate structure sizes ranging from one to several hundred radio wavelengths. For a wavelength of about 1 meter, it appears as though 5 percent of the surface consists of irregularities of comparable size. The remainder appears to be a random distribution of "smooth" surfaces which extend horizontally perhaps for 10-1000 meters and have an rms slope of 5°-8°. The dielectric constant ϵ of the surface materials is not known with precision, but the best estimates yield a value $\epsilon = 2.7$. It is interesting to note that this is close to the value for terrestrial sand.

A64-12640
FOSSIL METEORITE CRATERS.
C. S. Beals, M. J. S. Innes, and J. A. Rottenberg (Dominion Observatory, Ottawa, Canada).
IN: THE MOON, METEORITES, AND COMETS. Vol. IV - The Solar System.
Edited by Barbara M. Middlehurst and Gerard P. Kuiper.
Chicago and London, University of Chicago Press, 1963, p. 235-284. 50 refs.

Development of an analytical theory of crater formation by meteorites on the Earth's surface, on the basis of rheological considerations and the theory of propagation of three-dimensional finite-amplitude waves. The picture of a typical meteorite crater, developed from the crater theory, is used to derive the types of remnants or fossil structures likely to be left after hundreds of millions of years. Examined in detail are the physical characteristics of several representative craters. Existing hypotheses on the mechanisms of formation of lunar craters are reviewed.

A64-12680
MODIFICATION OF THE LUNAR SURFACE BY THE SOLAR-WIND BOMBARDMENT.
G. K. Wehner, C. E. Kenknight, and D. Rosenberg (General Mills, Inc., Electronics Div., Minneapolis, Minn.).
Planetary and Space Science, vol. 11, Nov. 1963, p. 1257-1261. 11 refs.
Contract No. NASw-424.

Experimental estimate of the sputtering rates for an unprotected body like the Moon in orbit around the Sun, and investigation of the modifications of the target surfaces bombarded by solar wind. Long-duration, solar-wind sputtering conditions were simulated at a much accelerated scale with mass-separated hydrogen ion beams or in low-pressure, noble gas or hydrogen plasmas. Experiments with metal targets and metal-, oxide-, and rock-powder samples demonstrate the leveling and smoothing of macroscopic surface features, and cementing together of loose particles into a porous, brittle, fibrous crust. Certain oxide surfaces become enriched with metal atoms under the bombardment and sputtering action. It is concluded that many of the unusual properties of the lunar surface can be explained by the action of solar-wind bombardment.

A64-12691
EROSION AND DEPOSITION ON THE MOON.
Gilbert Fielder (London, University, Observatory, London, England).
Planetary and Space Science, vol. 11, Nov. 1963, p. 1335-1340. 42 refs.

Discussion and tabulation of factors causing lunar erosion and deposition. A rate of extrinsic erosion of $\ll 6.10^{-4}$ cm year^{-1} is deduced from direct observations of the Moon's surface, and space data are used to set limits to the erosion produced by micrometeorites. The upper limit is $\sim 10^{-6}$ cm year^{-1}, and Gold's dust theory is discussed in the light of this result. It is concluded that, on the Moon, intrinsic erosion is more important than extrinsic erosion.

A64-12764
COSMIC RAY HAZARDS IN THE SOLAR SYSTEM.
S. N. Milford (Grumman Aircraft Engineering Corp., Research Dept., Bethpage, N.Y.).
American Institute of Aeronautics and Astronautics, Aerospace Sciences Meeting, New York, N.Y., Jan. 20-22, 1964, Preprint 64-66. 14 p. 60 refs.
Members, $0.50; nonmembers, $1.00.
Contract No. NASw-699.

Consideration of direct measurements of cosmic ray energy and charge spectra near the Earth, and in interplanetary space near the Earth. The theory of the effects of planetary magnetic fields and atmospheres in modifying these spectra is discussed, together with the interaction of cosmic rays with the Moon's surface. Also discussed is the intensity of interplanetary cosmic rays in the outer solar system, partly using simple models of the interplanetary magnetic fields to give the resulting modulation of low energy interstellar cosmic rays as a function of distance from the Sun. The radiation doses are estimated for the various regions. It is concluded that the known hazard presented by cosmic rays is appreciable only for long-term space missions, such as one- or two-year trips to planets, or possibly for bases on the Moon or Mars, when unshielded total doses of $\sim$100 rem may be accumulated. Possible unknown hazards might arise from heavy nuclei in the inner solar system, in future missions, from high intensities of light or heavy nuclei in the outer solar system; however, shielding should not be too difficult for these cases.

A64-12771
STUDIES OF TOUCHDOWN STABILITY FOR LUNAR LANDING VEHICLES.
W. C. Walton, Jr., R. W. Herr, and H. W. Leonard (NASA, Dynamic Loads Div., Vibration and Dynamics Branch, Langley Research Center, Hampton, Va.).
American Institute of Aeronautics and Astronautics, Aerospace Sciences Meeting, New York, N.Y., Jan. 20-22, 1964, Preprint 64-94. 9 p.
Members, $0.50; nonmembers, $1.00.

Presentation of results of a study to establish practical procedures for predicting the tumbling motions which may result when a vehicle impacts on a penetrable surface which is in general not level, such as may occur during lunar landing. Various ways in which a four-legged vehicle could overturn are listed, and three simple formulas are given which permit quick calculation of stability boundaries on the approach velocities for any two-dimensional mode of overturning. Boundaries computed by the use of the formulas are then compared with the results of experiments with simple models. Stability boundaries computed are also shown for two configurations representative of current thinking with regard to lunar landing vehicles. Some of the more critical modes of overturning are identified, and effects on these modes of lowering the center of gravity of the vehicle are found. Briefly discussed are three-dimensional tumbling motions. Experimental results obtained with a simple model are presented, indicating that three-dimensional landings may impose more severe limitations on approach velocities and angles than two-dimensional landings.

A64-12902
LUNAR BASES.
Irwin Stambler.
Space/Aeronautics, vol. 40, Dec. 1963, p. 60-67.

Discussion of "LESA," the lunar exploration system for Apollo, presently in the initial study stage. The project calls for the study of the general concept of a lunar base made from prefabricated modules launched by Saturn 5s. It is noted that, if a circumlunar trajectory is used, the landing site must be in a band between the 23rd parallels of lunar latitude. The choice of a base site may be further restricted by the choice of a landing site for Apollo, and by the existence of a nearby source of water, which is likely to be found in areas of volcanic activity. Alphonsus is stated to be the most promising base site on the Moon, although not the only one. Several potential sites would enter the picture if landings could be made without following a circumlunar trajectory. Considered are methods for the extraction of water from lunar materials, digging on the Moon, doubling of a launch vehicle as a base module, the cost of Moon "labor," the doubtfulness of solar power, and the slowness of lunar travel. Design studies on lunar test facilities have been completed, and the simulation of lunar operations is being studied.

A64-12918
A REVIEW OF THE METEOROID ENVIRONMENT IN CIS-LUNAR SPACE AND ON THE LUNAR SURFACE.
D. C. Bradford and R. D. Dycus (North American Aviation, Inc., Space and Information Systems Div., Downey, Calif.).
American Institute of Aeronautics and Astronautics, Aerospace Sciences Meeting, New York, N.Y., Jan. 20-22, 1964, Preprint 64-63. 8 p. 14 refs.
Members, $0.50; nonmembers, $1.00.

Survey of the entire spectrum of masses and sizes of the meteoroid flux. The small amount of available data indicates the probable presence of at least a micrometeoroid cloud near the Earth. It is noted that the solution for the puncture-size meteoroid flux in cis-lunar space and on the lunar surface must depend on theoretical considerations. The only usable "bridge" at this time is that furnished by the gravitational lens. It is shown that there is a region of concentration at less than ~ 7 Earth radii, and that this concentration slowly decreases, with increasing radial distance, to an undisturbed space value of $\sim$ 78% of the near-Earth value. It is further shown that the lunar surface flux varies with the lunar phase, reaching a maximum of 55% of the near-Earth flux at the 1st quarter and decreasing to 23% at the 3rd quarter. Considerations of lunar secondary ejecta have not been included. It is considered possible that a final solution for the magnitude of the near-Earth flux must include the influences of the Earth's magnetic and electrical fields upon charged meteoroids, and of the other atmospheric drag.

A64-13135
BEARING CAPACITY OF SIMULATED LUNAR SURFACES IN VACUUM.
E. C. Bernett, L. D. Jaffe, E. P. Frink, H. E. Martens (California Institute of Technology, Materials Research Section, Pasadena,

Calif.), and Ronald F. Scott (California Institute of Technology, Dept. of Civil Engineering, Pasadena, Calif.).
AIAA Journal, vol. 2, Jan. 1964, p. 93-98.
Contract No. NAS 7-100.

Determination of the static bearing capacity of a granular material, consisting of dry, crushed olivine basalt, in air and in a 10^{-6}-mm-Hg vacuum by means of cylindrical probes with a range of diameters. Samples with various particle-size distributions are used for these tests. It is found that the packing density of these granular materials was the factor that had the greatest influence on the bearing capacity. The minimum bearing capacity of a loosely packed sample with a density of 1.25 g/cm^3 is about 0.1 kg/cm^2. The maximum bearing capacity of a densely packed sample with density of 2.1 g/cm^3 is about 7 kg/cm^2. The effects of vacuum are found to be insignificant compared with the effect of packing density. Direct shear tests indicate the cohesion in a few densely packed samples to be 1-2 x 10^4 dyne/cm^2. For the small probes used, the cohesion is estimated to contribute 85 to 95% of the observed bearing capacity for the densely packed samples but much less for the loosely packed samples.

A64-13230
THE NATURE OF THE LUNAR SURFACE LAYER [K VOPROSU O PRIRODE POVERKHNOSTNOGO SLOIA LUNY].
B. Iu. Levin (Akademiia Nauk, Institut Fiziki Zemli, Moscow, USSR).
Astronomicheskii Zhurnal, vol. 40, Nov.-Dec. 1963, p. 1071-1075. In Russian.

Brief discussion of the necessity for distinguishing between concepts of the true extremely nonhomogeneous structure of the lunar surface layer and the simple models used for the interpretation of radio astronomical and radiometric observations usually made with instruments of small resolving power. It is noted that the volume content of metallic iron in meteorites is small and, therefore, radioastronomic data are not in contradiction with the idea of the important role of the exogenic factor in the formation of the surface layer of the Moon.

A64-13232
THE ALBEDO VALUES FOR SEPARATE DETAILS OF THE LUNAR SURFACE [O ZNACHENIIAKH AL'BEDO DLIA OTDEL'NYKH DETALEI LUNNOI POVERKHNOSTI].
N. N. Sytinskaia.
Astronomicheskii Zhurnal, vol. 40, Nov.-Dec. 1963, p. 1083, 1084. In Russian.

It is shown that due to the specific characteristics of light reflection from the lunar surface, which are the same for both maria and continents, the values of the apparent albedo, measured during the full Moon for the separate details of the lunar surface, can easily be transformed into such reflectivity characteristics as geometrical and spherical albedos.

A64-13317
THE REFLECTION AND EMISSION OF ELECTROMAGNETIC RADIATION BY PLANETARY SURFACES AND CLOUDS.
D. G. Rea and W. J. Welch (California, University, Space Science Laboratory and Dept. of Electrical Engineering, Berkeley, Calif.).
Space Science Reviews, vol. 2, Oct. 1963, p. 559-617. 183 refs.
Grants No. NsG 101-61; No. NSF G-16741.

Review of recent theoretical and experimental studies of planetary surfaces by reflection and emission observation techniques. General considerations are presented of the theory of reflection from plane, layered, and rough surfaces, and from clouds. Principles underlying the radiometric determination of planetary temperatures are delineated. The behavior of the lunar surface in the visible region is discussed, and information obtained about the surface from radar reflections, infrared emission, and thermal emission at radio wavelengths is considered in some detail. Visible, near infrared, infrared, passive microwave, and radar observations of Venus are reviewed, as are such observations of Mars. Observations of Jupiter, Saturn, and Mercury are briefly summarized.

A64-13438
THE MOON'S PHOTOMETRIC FUNCTION.
Robert L. Wildey (California Institute of Technology, Div. of Geological Sciences, Pasadena; Carnegie Institution of Washington and California Institute of Technology, Mount Wilson and Palomar Observatories, Calif.).
Nature, vol. 200, Dec. 14, 1963, p. 1056-1058.

Presentation of a simple observational test, in the case of the inner slopes of lunar crater rims, of the double assumption that: (1) the general photometric function of the lunar surface applies to the inner walls of crater rims, and (2) the functional form of the photometric function which has been fitted to previous photographic data is correct.

A64-13744
HISTORY OF LUNAR ATMOSPHERE AND THE PROBABILITY OF THE PRESENCE OF ICE AND ORGANIC COMPOUNDS ON THE MOON [HISTORIA KSIĘŻYCOWEJ ATMOSFERY I PRAWDOPODOBIEŃSTWO WYSTĘPOWANIA LODU I ZWIĄZKÓW ORGANICZNYCH NA KSIĘŻYCU].
V. S. Safronow and E. L. Rouskol.
Astronautyka, vol. 6, May 1963, p. 1-4. 13 refs. In Polish.

Discussion of a possible lunar atmosphere on the basis of modern theories of the formation of the Moon and of the history of lunar thermal evolutions. An analysis of the composition, age, and the maximum fluctuations in atmospheric density leads to revised conclusions on the presence of ice and organic compounds on the Moon.

Subject Index

Listings of Subject Headings of Reports

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